ELECTROMECHANICAL

components & systems **DESIGN**

APRIL 1961

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James Flora

in this issue · components digest 21 · semiconductor devices in electromechanical engineering

NEW DEPARTURES IN MINIATURE

ULTRA-CLEAN INCUBATORS FOR M/I* BALL BEARINGS

N/D'S NEW WHITE ROOM PROVIDES ULTRA-CLEAN ENVIRONMENT FOR M/I BALL BEARING ASSEMBLY

N/D announces a new White Room at Sandusky, Ohio incorporating the latest technological advances available today. This new room provides a virtually dust-free atmosphere so necessary for the production of Miniature and Instrument Ball Bearings of high reliability.

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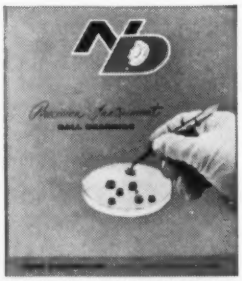
*Miniature and Instrument Ball Bearings.



SEND FOR NEW DEPARTURE'S M/I BALL BEARING CATALOG TODAY. WRITE DEPT. L. S.

NEW DEPARTURE

MINIATURE AND INSTRUMENT BALL BEARINGS

CIRCLE NO. 1 ON INQUIRY CARD

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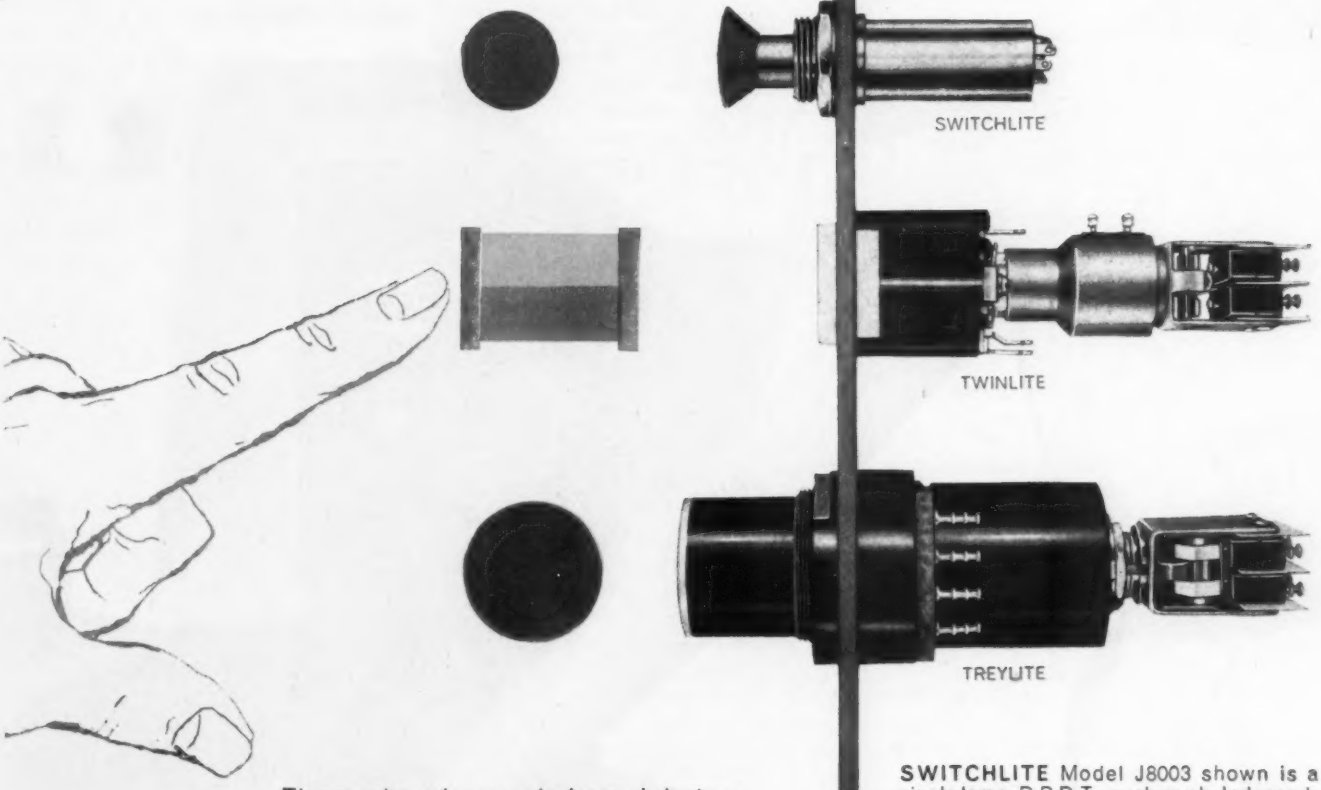
CUT CONTROL PANEL COSTS AND SAVE SPACE WITH COMBINED SIGNAL & SWITCH



The most modern control panel designs combine indicator lights and pushbutton switches wherever possible. This cuts costs by reducing the number of components, and speeds assembly. Overall panel size can often be reduced as much as 75%. And these "human-engineered" controls sell better because operation is obviously simplified. Here are just three of the many lighted pushbuttons available from Control Switch Division...

SWITCHLITE Model J8003 shown is a single lamp, D.P.D.T., push-push. Independent lamp circuit for 6, 14 or 28 volts. Rated 3 amp res., 1 amp ind. @ 28 VDC or 115 VAC. Mounts in ⅝" dia. hole. 4 button styles, several lens colors.

TWINLITE . . . two lamps with independent circuits for 2-color lighting. Lens 1" x .740" in solid or split colors, with or without nameplate slot. Momentary or push-push action, or solenoid-held switch shown above. Rated 4 amp res., 2.5 amp ind. @ 30 VDC; 5 amp @ 125/250 VAC. Mount in groups or singly, using barriers.

TREYLITE . . . three independent lamps, each with color filter so three colors can be sequenced on white pushbutton screen. D.P.D.T. switch rated 4 amp res., 2.5 amp ind. @ 30 VDC; 5 amp @ 125/250 VAC. Select momentary or push-push action. Models for flush-panel mounting (shown above) or subpanel mounting.

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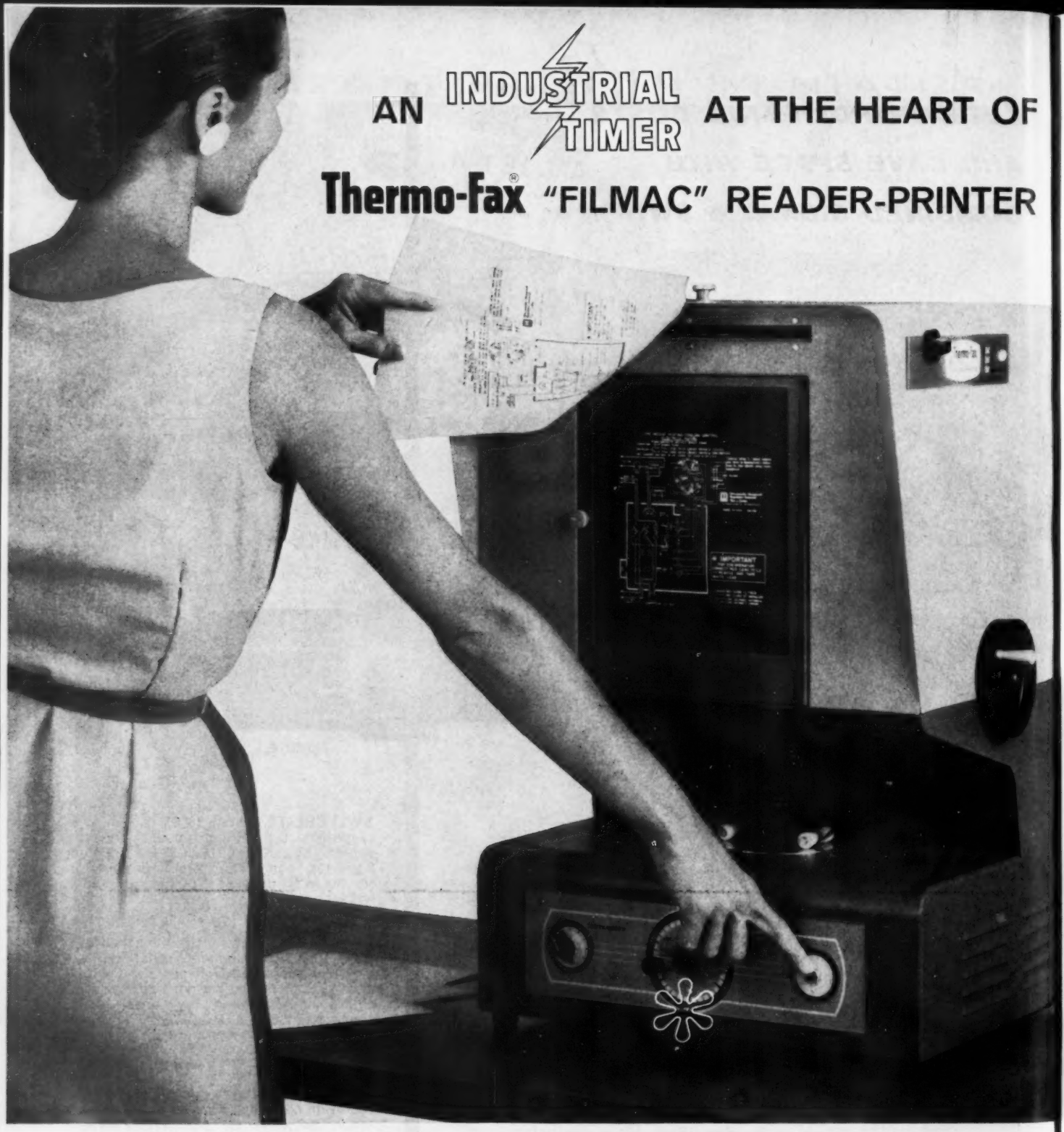
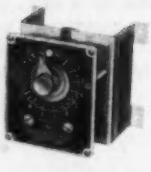
AN INDUSTRIAL TIMER AT THE HEART OF Thermo-Fax® "FILMAC" READER-PRINTER

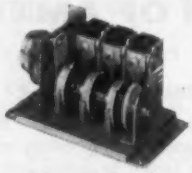


INTERVAL TIMERS



TIME DELAY TIMERS

RUNNING TIME METERS



RECYCLING TIMERS

Time is of the essence in making sharp, crisp copies from microfilm. To assure prints up to the fullest quality potential of the THERMO-FAX "Filmac 100" Reader-Printer, Minnesota Mining and Manufacturing Company specified a time delay timer that would combine ultra-reliability, simplicity, and ease of operation at the right price. It was specially made by Industrial Timer Corporation to Minnesota Mining and Manufacturing's specifications.

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CIRCLE NO. 3 ON INQUIRY CARD

ELECTROMECHANICAL components & systems DESIGN

The Sourcebook of Design Ideas in Applied Electromechanics

APRIL 1961 • VOL. 5 NO. 4

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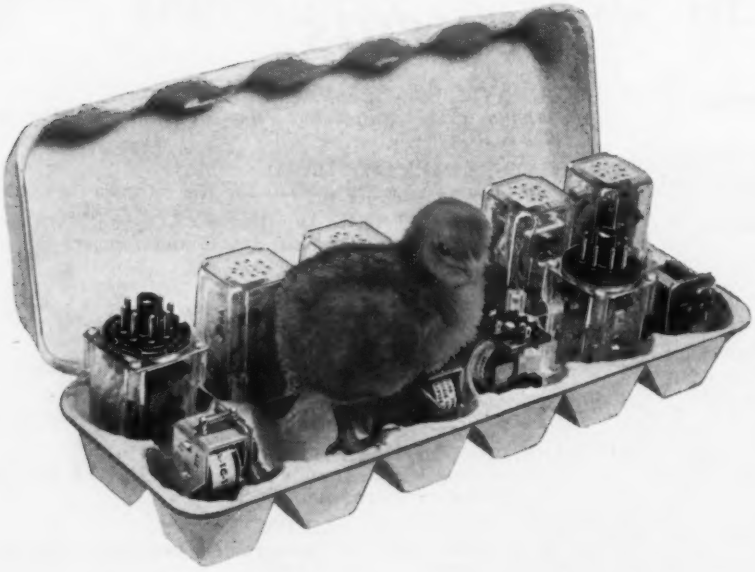
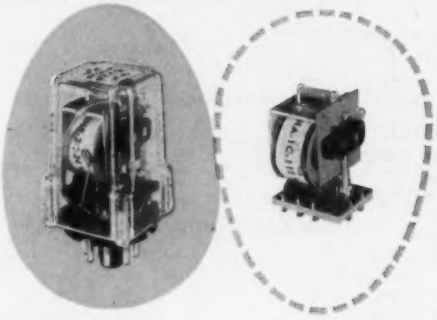
which comes first...



the relay or the need?

Engineers at Elgin Advance are constantly working to keep Elgin Advance Relays up to the state-of-the-art. They strive to make each relay you *buy* today the relay you *need* today. When you specify relays, specify Elgin Advance—you'll get the relay that matches your *needs*.



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- GHB — 10 amp resistive contact rating
- GHE — 5 amp plate-circuit type

Contact arrangements are SPDT, DPDT and 3PDT

GHA and GHB AC pull-in power is from 2 to 3VA; DC from 1 to 2 watts

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CIRCLE NO. 4 ON INQUIRY CARD

ELECTROMECHANICAL
components & systems DESIGN

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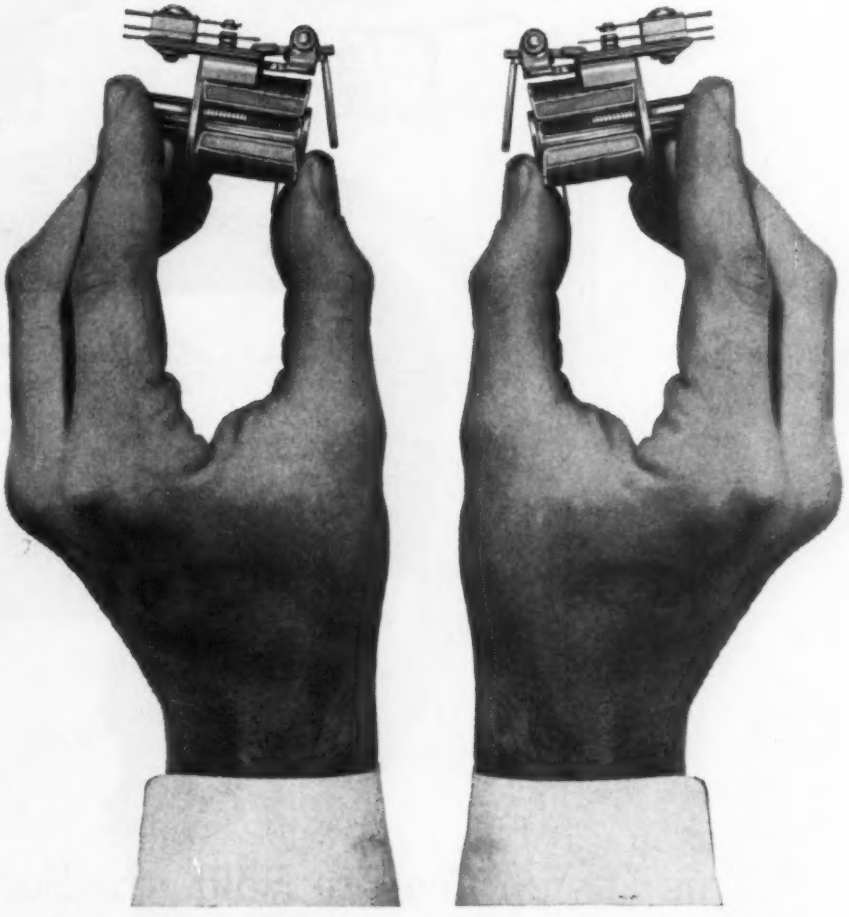
DELAY RELAY? LOAD RELAY?
BOTH!



The Type A Silic-O-Netic Relay is a light, small time-delay relay. *It weighs a mere three ounces, gives you any delay you spec from 0.25 to 120 seconds. Keeps at it, too, for several million operations; the time-delay element cannot stick, bind, or wear.*

The Type A Silic-O-Netic Relay is a light, small load relay. *The continuous-duty coil does the trick. The Silic-O-Netic can be energized continuously, eliminating lock-in auxiliary circuits. Saves wire. Saves work. Saves space. Saves money.*

Here, then, is a time delay relay that doubles as a load-carrier. The Type A offers SPDT or DPDT switching, with contact capacity up to three amps. Consumes, at most, two watts of AC power, three watts of DC. Available for use on one of twenty standard AC and DC operating voltages, and on request, for others. Costs far less than the two relays you would need to replace it; well worth a closer look. Write for Bulletin 5003.

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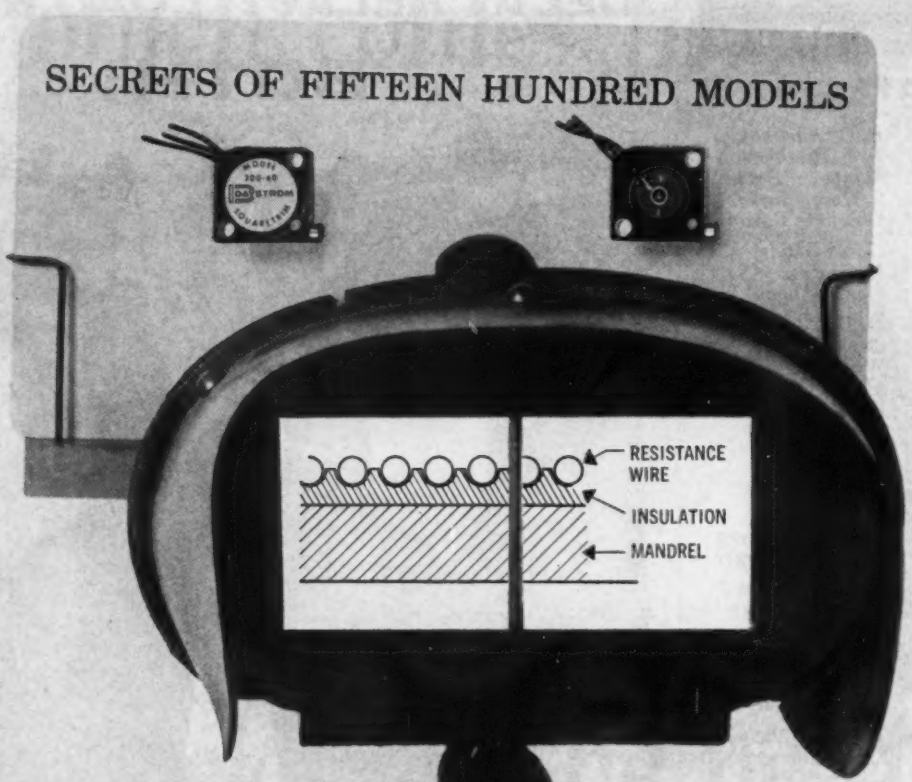

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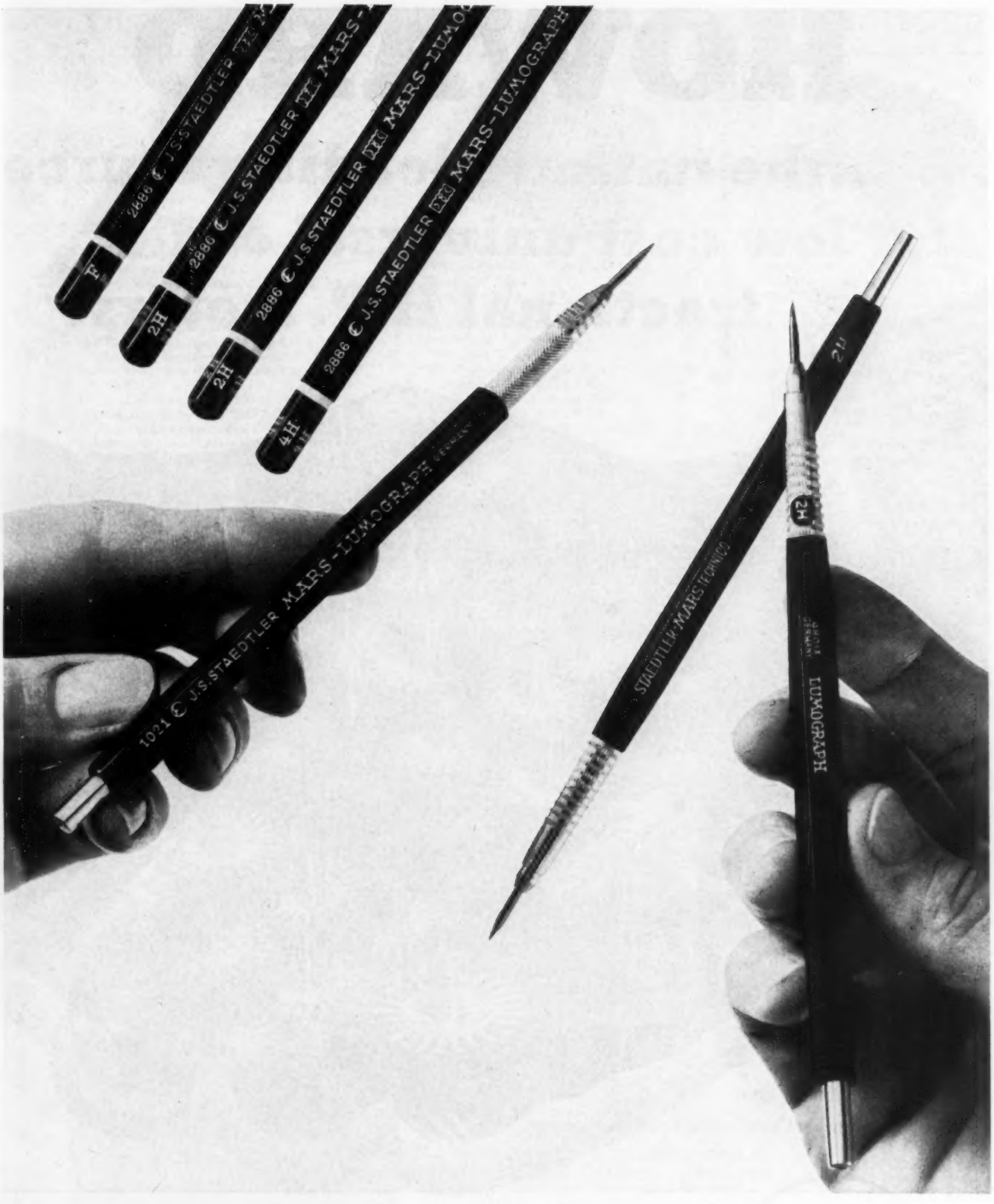

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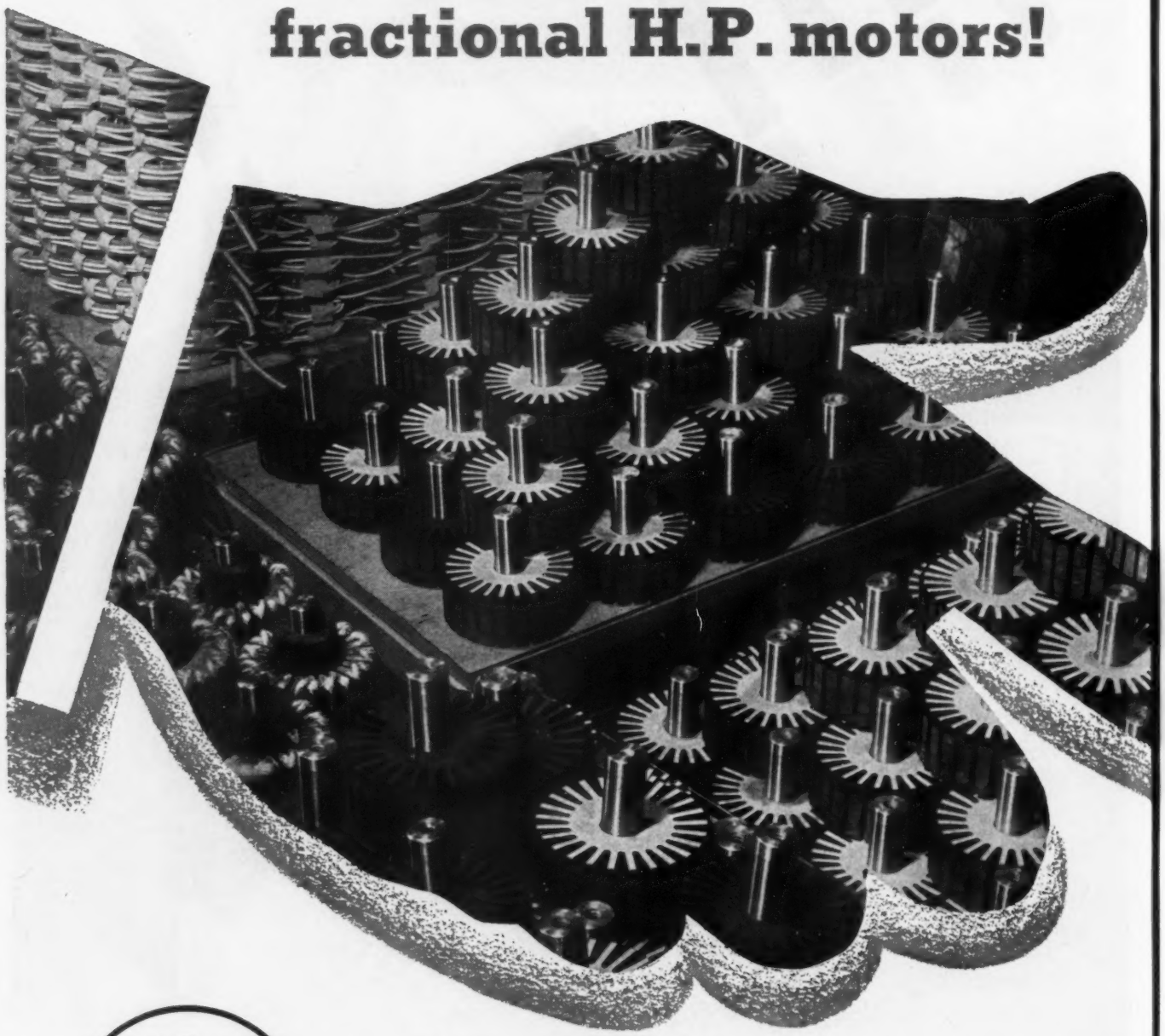

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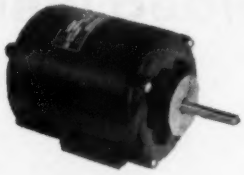
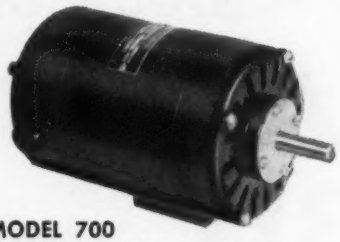
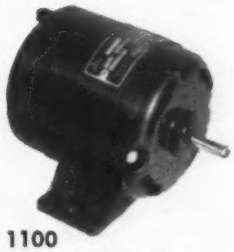


MODEL 29-500
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-5/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.



MODEL 700
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.800".
LENGTH: 5-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.



MODEL 1100
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

MODEL 243
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—5000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.

MODEL 200
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 512
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/5 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.

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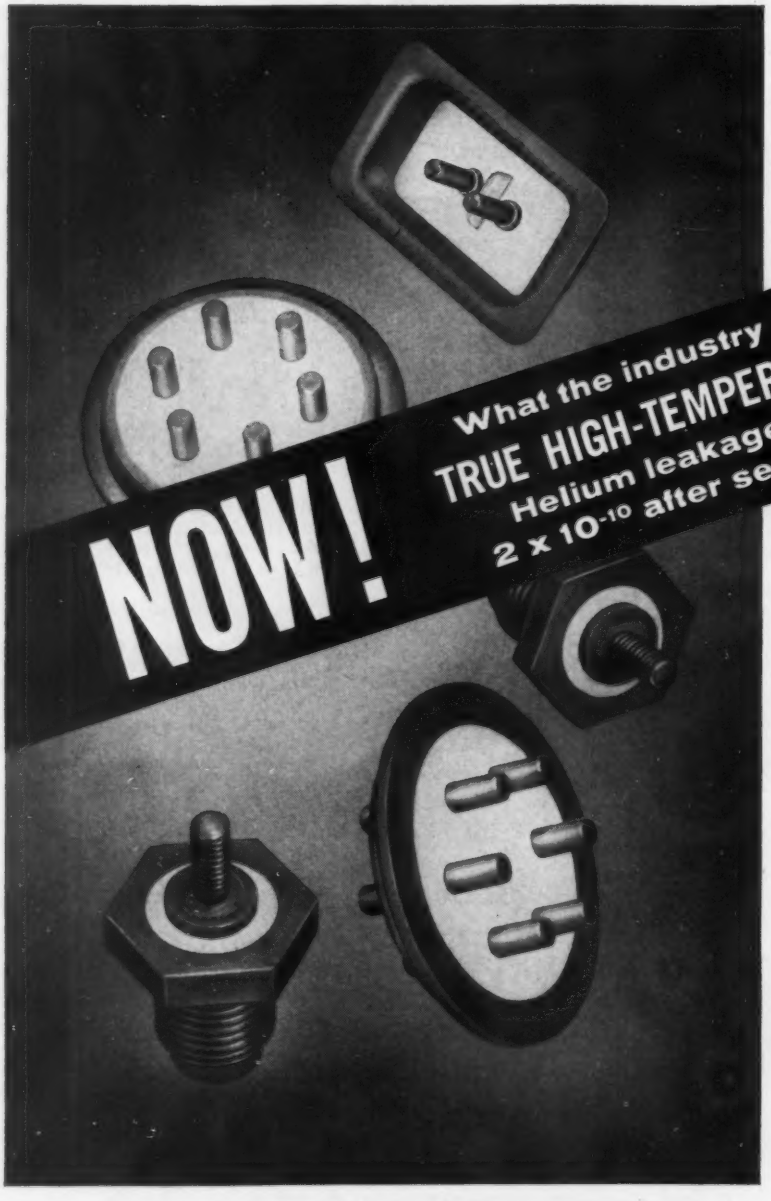
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COMPONENTS DESIGN

PNEUMATIC JET-PIPE VALVE

By K. N. Reid, Jr., *Dynamic Analysis and Control Lab., Dept. of Mech. Engrg., M.I.T.*

Although the jet-pipe valve has been in use for many years, the extremely complex nature of the flow field has made a theoretical analysis very difficult, even for simple cases using incompressible fluid. In a paper presented at the First International Congress of the International Federation for Automatic Control, held in Moscow, the author described the results of a series of carefully planned tests of a jet-pipe valve operating with compressed air. The test results established, for maximum power transfer from valve to load, the following design criteria:

- *Receiving hole diameter-to-nozzle diameter should equal approx. 1.4.*
- *Nozzle-to-receiving hole spacing should be within 0.2 of the nozzle diameter.*
- *Pressure supply to jet-pipe should be as high as possible.*

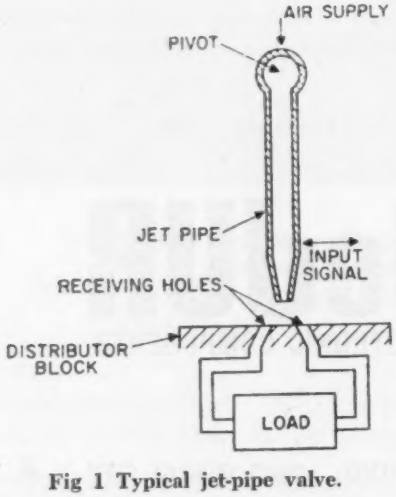


Fig 1 Typical jet-pipe valve.

Of major importance in the development of pneumatic control systems is the design of efficient and reliable pilot valves. One potentially useful pilot valve, where high performance, simplicity, reliability, and low cost are important, is the jet-pipe valve.

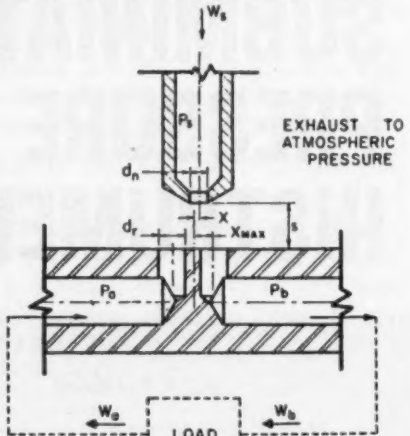
The jet-pipe valve, shown in Fig 1, consists of two major components: a nozzle and a distributor or receiving block. The nozzle serves to convert available energy of the high pressure supply into kinetic energy of a jet and to direct this jet toward the two holes in the distributor block. At the distributor block, the kinetic energy of the jet is converted into usable controlled energy. When the nozzle points directly between the two receiving holes, no pressure difference exists across the load. However, if the nozzle is directed more towards one receiving hole, the pressure on that side of the load increases whereas the pressure on the opposite side of the load decreases. This pressure difference will produce a force on the load.

Several features of the jet-pipe valve make its use as a control element very attractive. Construction of the valve is extremely simple. The dimensions of the parts are not very critical, thus resulting in economy and ease of manufacture. Usually very small forces are required to actuate the jet pipe, and stiction problems are of little concern. The nature of operation of the valve requires no tight tolerances between valving elements, thus suggesting a high degree of reliability even with contaminated fluids.

There are, of course, inherent disadvantages associated with the jet-pipe valve. The valve is open centred and therefore is load-sensitive, that is, a finite jet-pipe displacement is required to build up a differential pressure across the load. In comparison with a closed centre valve, the jet-pipe valve is very inefficient owing to its large quiescent leakage. A major drawback of the valve seems to be the relatively large jet-pipe motion required to establish maximum power transfer to the load.

Design Parameters

The important geometric parameters are shown in Fig 2. In general, a relation-



LEGEND:

X = VALVE STROKE
d_n = JET NOZZLE DIAMETER
d_r = RECEIVING HOLE DIAMETER
S = NOZZLE TO RECEIVER SPACING
W_s = SUPPLY FLOW (WEIGHT)
Q_s = SUPPLY FLOW (VOLUMETRIC) AT P_s
P_s = SUPPLY PRESSURE
P_m = LOAD PRESSURE
W_a = FLOW IN CHAMBER a (WEIGHT)
W_b = FLOW IN CHAMBER b (WEIGHT)
Q_a = FLOW IN CHAMBER a (VOLUMETRIC) AT P_a
Q_b = FLOW IN CHAMBER b (VOLUMETRIC) AT P_b
$W_m = W_a = W_b$ FOR RESISTIVE LOAD
$Q_m = Q_a = W_b$ FOR IDEALIZED RAM LOAD

Fig 2 Jet-pipe valve parameters.

ship will exist between the jet-pipe position x, the pressure drop across the load P_m, and the weight rate of flow (or the volume rate of flow Q_m, depending on the nature of the load interacting with the valve) of air through the load W_m. For conditions of steady x, P_m and W_m, this relationship is known as the steady-state valve characteristic.

Preliminary tests with a very simple jet-pipe valve were made in order to determine qualitatively the effect of various geometric and operational parameters on the steady-state performance of the valve. The tests revealed that the steady-state valve characteristics were strongly dependent on the following parameters: relative sizes of jet-pipe nozzle and receiving holes; spacing between nozzle and receiving holes; and pressure level of jet-pipe supply.

Analysis of Experimental Data

A versatile test fixture, designed and constructed in the Dynamic Analysis and Control Lab. of M. I. T. was employed for the experimental work. Fig 3 is a schematic diagram of the test set-up.

Initially, data were taken to determine the effect of the nozzle-to-receiving hole spacing on the full stroke (when the nozzle is aligned with one of the receiving holes) characteristic curve. To simplify the work, only the two end-points of the curve were measured for different spacings: the blocked-load (no flow through the load) static pressure recovery and the zero-load (no pressure drop across the load) flow recovery. These end-point data are presented in Fig 4 for three different receiver diameter-to-nozzle diameter ratios. The measured values of blocked-load pressure recovery ($W_m = O$) are non-dimensionalized with respect to the maximum pressure recovery. Likewise, the measured values of the zero-load flow recovery ($P_m = O$,) are non-dimensionalized with respect to the maximum flow recovery. The spacing is non-dimensionalized with respect to the nozzle diameter.

In general, the curves fall off rapidly as the spacing is increased, especially as compared with a hydraulic jet-pipe valve. The unusual shape of the curves has not been explained but the data were found to be repeatable. Evidently for best recovery conditions the spacing should be as small as possible. Of course if the nozzle is too close to the distributor block, the valve loses its advantageous feature of being dirt-insensitive.

The effect of the receiver diameter-to-nozzle diameter ratio on the steady-state characteristics could not be determined until a decision was made

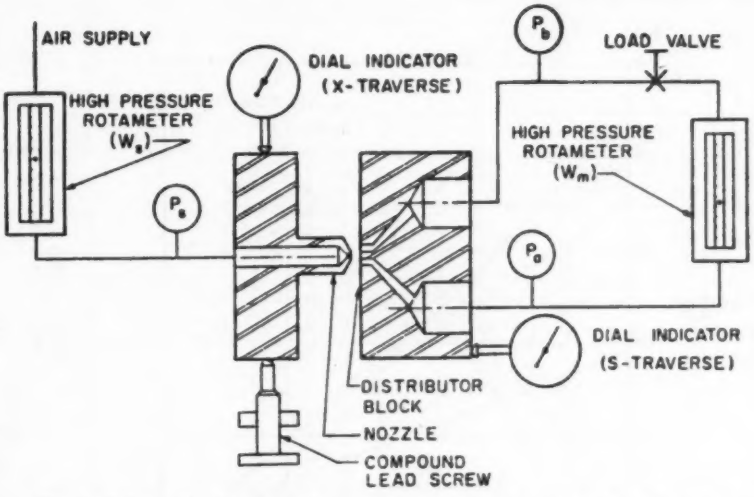


Fig 3 Schematic diagram of test setup. The jet-pipe stroke x was adjusted by a differential lead screw and measured by a precision dial indicator. The nozzle-to-receiving hole spacing s was also measured with a dial indicator. Pressures were measured with standard Bourdon-type gauges and flows were measured with a calibrated high-pressure rotameter. The relative sizes of the jet-pipe nozzle and receiving holes were varied by employing a series of different nozzles (0.016 in. diam., 0.022 in., 0.031 in., 0.043 in.) and a single distributor block. The receiving holes were 0.031 in. in diameter and were spaced 0.046 in. on centres leaving 0.015 in. of wall between. These dimensions were selected because they gave promise of providing information needed by the Mason-Neilan Co. in the evaluation of jet-pipe controlled process valve actuators.

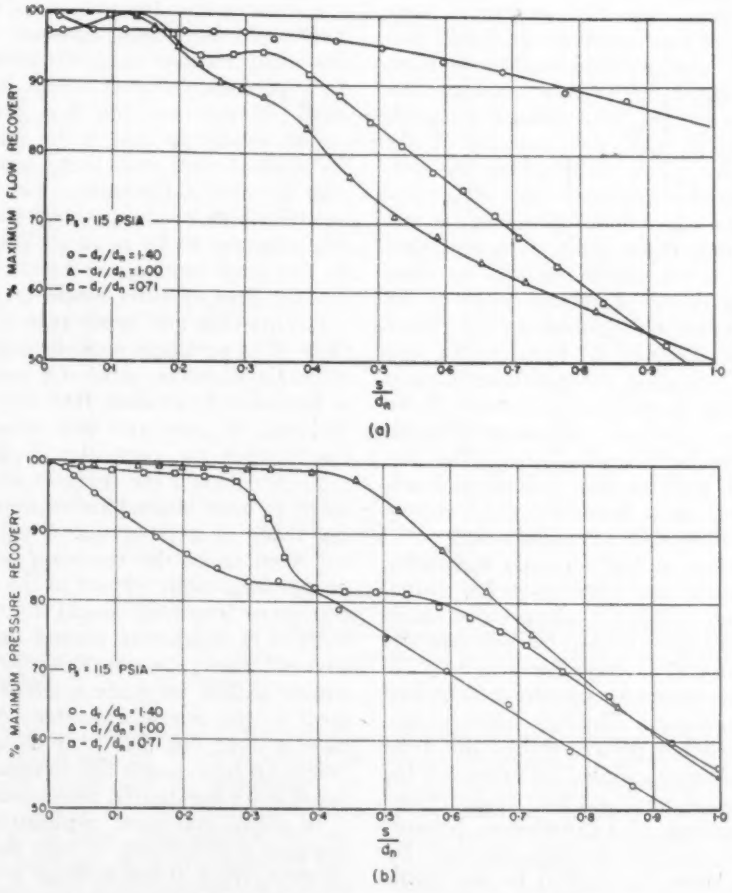


Fig 4 Effect of nozzle to receiving hole spacing on pressure and flow recovery characteristics for various d_r/d_n.

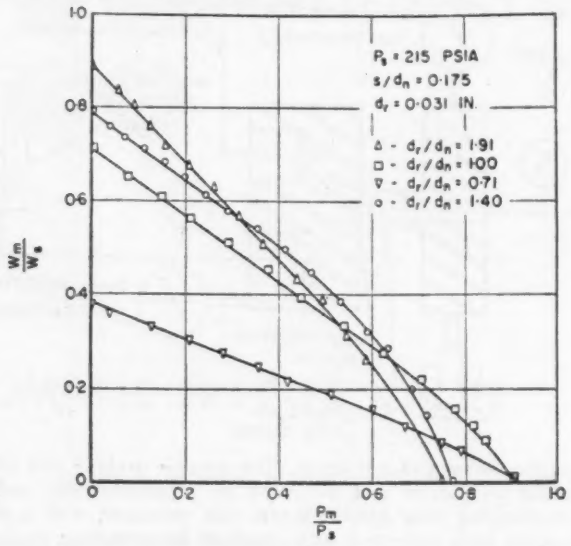


Fig 5 Full stroke dimensionless pressure-flow curves for $s/d_n = 0.175$ and various d_r/d_n.

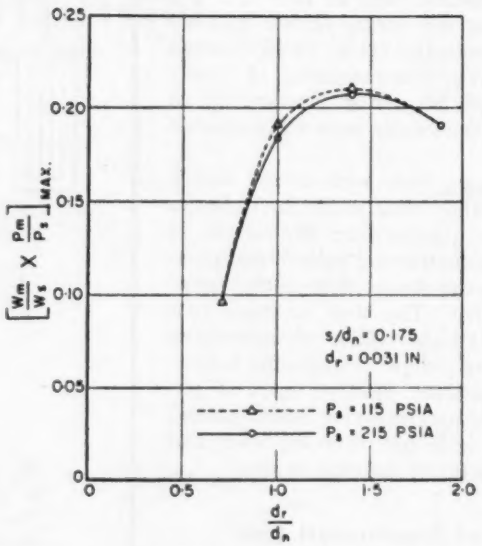


Fig 6 Maximum dimensionless power transfer to load for various d_r/d_n.

concerning what nozzle-to-receiving hole spacing or spacings should be used. It seemed that two situations were worthy of consideration and might possibly fit most practical conditions. First, the designer might insist on some reasonable spacing (s = constant) regardless of the size and capacity of the particular valve. In this case, the dirt-insensitivity advantage of the valve could be maintained. However, as evident from the spacing data presented in Fig 4, performance would be sacrificed if nozzle diameters were of the same order of magnitude as the chosen spacing. Second, for the designer who would look upon the experimental valve as a scale model, a comparison of the different receiver diameter-to-nozzle diameter ratios might logically be performed holding the spacing-to-nozzle diameter ratio constant (s/d_n = constant) instead of s = constant.

In view of the previous discussion, full stroke data were taken for several different receiver diameter-to-nozzle diameter ratios when: s = constant and $s/d_n = 0.175$. Data for $s/d_n = 0.175$ are presented in non-dimensionalized form in Fig 5. The data for s = constant are not presented but the same general results apply. Of interest is the increase of zero-load flow recovery and the decrease of blocked-load pressure recovery as the receiver diameter becomes larger in relation to the nozzle diameter. These results are no surprise when one considers the closely related problem of a jet impinging on an infinite flat plate. This flat plate model might approximate the condition of a very small receiver and a large nozzle. It is evident that the pressure distribution would be almost constant across the small receiver and therefore the static pressure recovery would be very good. In contrast, the flow recovery would necessarily have to be small. If the receiver were made large, compared with the nozzle, the nature of the pressure distribution would require the pressure recovery to be smaller. However, for this large receiver we see intuitively that the flow recovery would be larger.

The question now arises as to whether there is an optimum receiver diameter-to-nozzle diameter ratio. Of course it is immediately evident that this question can be answered only when one knows what the particular application requires. Should the designer wish the valve to have characteristics approaching those of a flow control valve, he will then make the receiving hole diameter large with respect to the nozzle diameter. However, should the characteristics of a pressure control valve be desired, then the receiving hole diameter should be made small with respect to the nozzle diameter. Neither case is clear cut, but final design depends on how much the designer will sacrifice for the desired performance.

In many important applications the designer might desire to have the most efficient valve possible from a power transfer standpoint. Thus the maximum power transfer between the nozzle supply and the load might be a logical compromise and serve as one particular criterion of merit for the valve. The maximum non-dimensionalized 'power transfer' (maximum value of $W_m/W_s \times P_m/P_s$) for each receiver diameter-to-nozzle diameter ratio is plotted in Fig 6. The reader should note that the term 'power transfer' does not represent the power transferred to a ram-type load. The concept of power transfer used here is somewhat fictitious but serves as a convenient way to compare the steady-state characteristics of different valve configurations. The peak of the curve in Fig 6 represents the optimum ratio of receiver diameter-to-nozzle diameter for the largest maximum power transfer. An approximate value of $d_r/d_n = 1.4$ is found to represent the optimum ratio for both of the spacing cases discussed ($s/d_n = 0.175$ and s = constant) as well as for supply pressures of 115 and 215 lb/in.^{2} absolute.

The effect of supply pressure level on the characteristics of the optimum configuration (based on maximum power transfer) is shown in Figs 7 and 8. Figure 7 shows how the blocked-load pressure recovery and zero-load flow recovery depend on nozzle supply pressure. Figure 8 shows the full stroke pressure-flow characteristic curve for several supply pressures. Of particular interest is the inefficiency of the valve (from the standpoint of power transfer) at low supply pressures. It is interesting to note that at very low supply pressures the load flow is greater than the supply flow, indicating that the valve is behaving as a jet-pump.

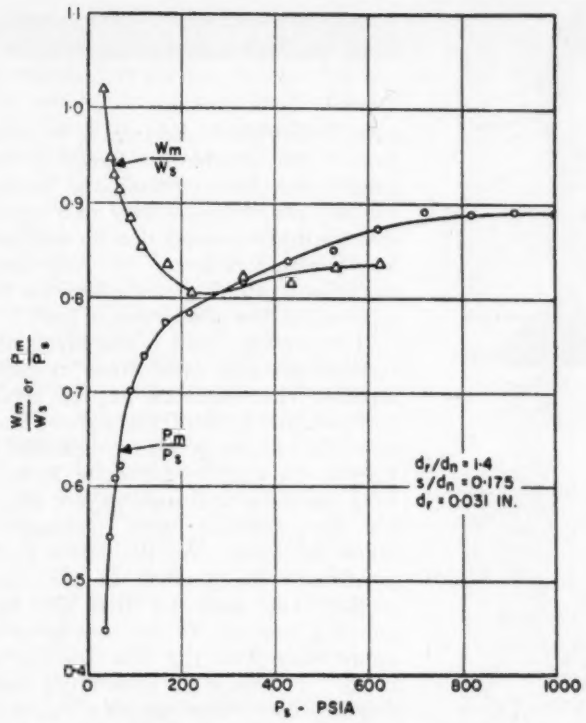


Fig 7 Dimensionless blocked-load pressure recovery and zero-load flow recovery versus supply pressure.

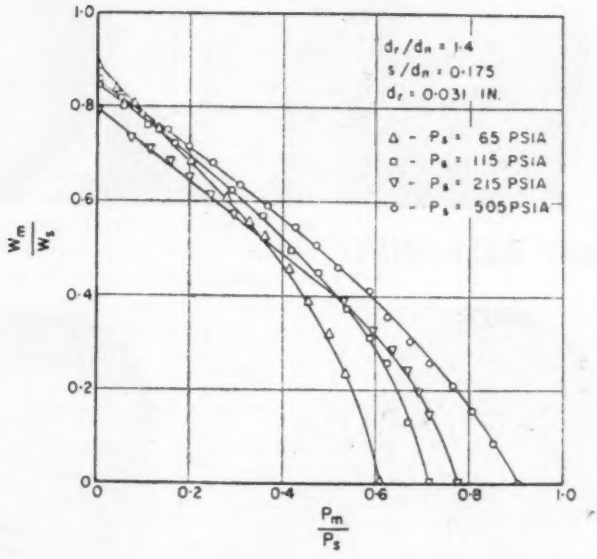


Fig 8 Full stroke dimensionless pressure-flow curves for various P_s.

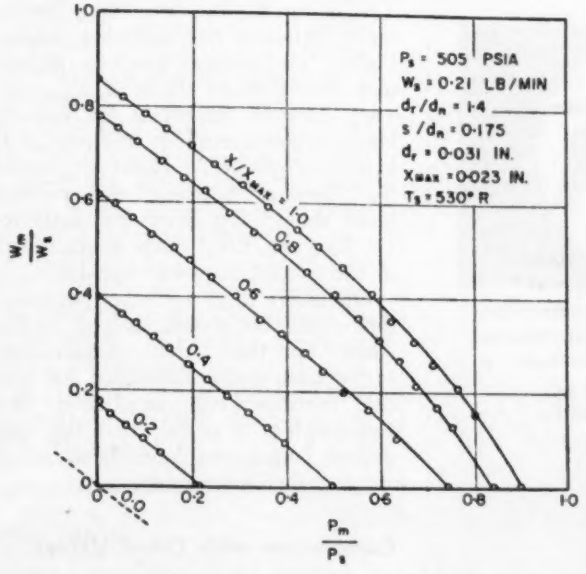


Fig 9 Dimensionless pressure-flow-displacement characteristics of a pneumatic jet-pipe valve with a resistive load. At origin $P_a = P_b = 210$ lb./in.^{2} absolute.

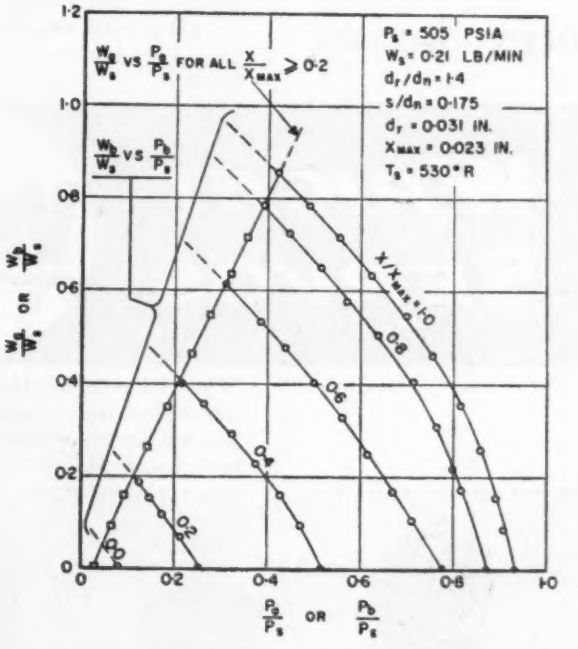


Fig 10 Dimensionless pressure-flow-displacement characteristics of a pneumatic jet-pipe valve for an arbitrary load.

As mentioned previously, the steady-state pressure-flow-displacement characteristics of the valve are of utmost importance to the systems designer. The most useful method of presenting these characteristics is largely dependent on the nature of the load interacting with the valve. For instance, if a resistive-type load is employed, the weight rates of flow entering and leaving the load are equal. In such a case, the steady-state characteristics for the complete four-way valve may be represented as shown in Fig 9. The relatively even spacing of the intersections of the curves with the flow and pressure axes indicates that the flow sensitivity (zero-load flow recovery versus jet-pipe displacement) and the pressure sensitivity (blocked-load pressure recovery versus jet-pipe displacement) curves are quite linear throughout a large part of the maximum jet-pipe displacement.

In practice, commonly encountered loads comprise a combination of resistance, capacitance, and inertia. A good example is the case of a ram-type load. The weight rates of flow entering and leaving the two ram chambers are generally not equal, except for the special

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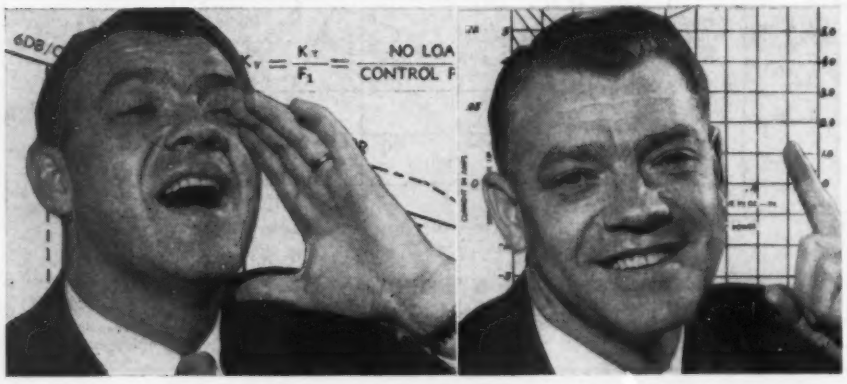

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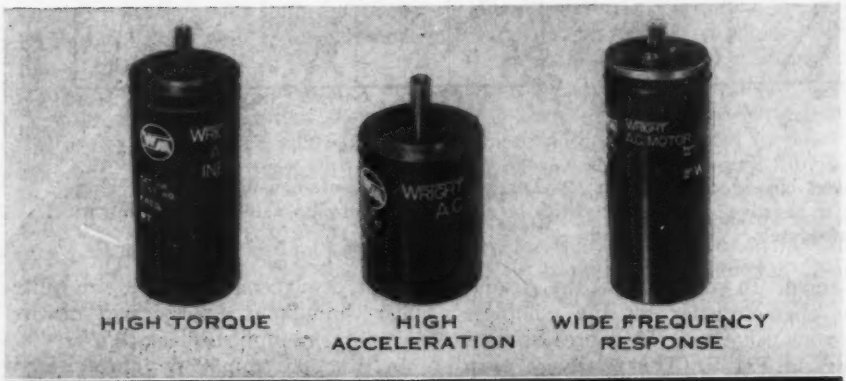

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case of no pressure drop across the load. In fact, for steady-state operation the volume flow rates entering and leaving the ram chambers are very near equal. It is worthwhile noting that the blocked-load pressure recovery (no movement of the load or flow past the load) is the same regardless of the type of load.

If a ram-type load is employed, the systems designer must have available separate characteristics for the intake and exhaust sides of the valve. Such individual characteristics are plotted in Fig 10, for positive values of X/X_{max}, from the same data used to plot Fig 9. For the particular valve configuration under discussion, W_a/W_s versus P_a/P_s is virtually independent of the valve stroke. This indicates that the flow entering receiver "b" does not interfere appreciably with the flow leaving receiver "a" except at very small valve displacements. For negative values of X/X_{max}, Fig 10 is also valid if subscripts a and b are interchanged.

It is of interest to note that the blocked-load pressure recovery, when $X/X_{max} = 0$, may be varied by changing the distance between the receiving holes. For the configuration discussed here, $P_a/P_s = P_b/P_s = 0.08$ when $X/X_{max} = 0$. By decreasing the distance between the receiving holes, a higher blocked-load pressure recovery may be obtained when $X/X_{max} = 0$ (this may be important for ram-type loads where maximum stiffness of the load is desirable). However, varying the distance between the receiving holes should not affect the full-stroke ($X/X_{max} = 1.0$) valve characteristics or the maximum power transfer.

Obviously there are other parameters that could be investigated as to their effect on the valve characteristics. Many have been eliminated for intuitive reasons not mentioned here. Nevertheless it is felt that the major design parameters have been investigated rather extensively.

Comparison with Other Valves

Characteristics of a pneumatic jet-pipe valve are surprisingly similar to those of a hydraulic jet-pipe valve. Unpublished work in the Dynamic Analysis and Control Laboratory of M.I.T. has indicated that the optimum receiver diameter-to-nozzle diameter is also approximately equal to 1.4 (on the basis of a maximum power transfer criterion). The major difference between the two valves is the dependence of the valve characteristics on the nozzle-to-receiver spacing. As mentioned earlier, the blocked-load pressure

recovery and the zero-load flow recovery for the pneumatic valve fall off quite rapidly even when the spacing is of the same order of magnitude as the nozzle diameter. In contrast, these characteristics remain virtually the same for the hydraulic valve, even for spacings as large as five times the nozzle diameter.

It is interesting to compare the pneumatic jet-pipe valve with the more commonly used four-way flapper-nozzle valve. Both valves are simple, easy to manufacture, reliable and reasonably insensitive to contamination. In addition, both valves are classed as open-centered and therefore share the disadvantages of load sensitivity and high quiescent leakage. In contrast, the flapper nozzle valve requires a relatively large operating force to overcome an inherent pressure feedback effect. It has been indicated that the flapper-nozzle valve has only about one-half the maximum power transfer, for the same total supply flow, as presented here for the pneumatic jet-pipe valve (this is also true for the hydraulic case).

The spool valve has often been employed in the same applications as the jet-pipe and flapper-nozzle valves (first stage of two-stage valves or single-stage valves). The spool valve is characterized by high internal friction and dirt sensitivity, features relatively uncommon to the latter two valves. Valves using spools directly stroked by a torque motor usually require the introduction of dither to overcome the effects of internal friction. Dither is usually unnecessary in most applications employing the jet-pipe or flapper-nozzle valve. It is interesting to note that the fluid splashing away from the distributor block of the jet-pipe valve often produces a small random force disturbance on the nozzle in the signal direction. This has the effect of a deliberately introduced dither. Generally speaking, the jet-pipe valve and the spool valve have comparable power transfer, both being superior to the flapper-nozzle valve in this respect • • •

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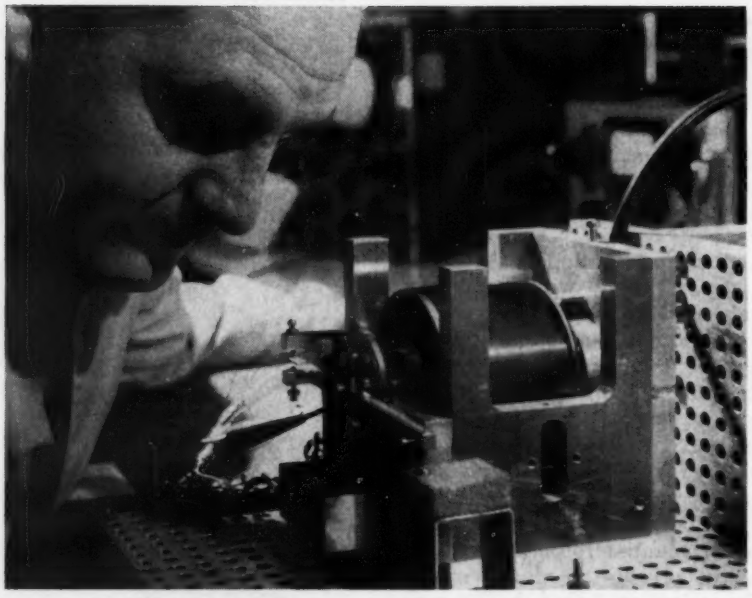

Fig 1 Engineer at Sperry Gyroscope Co. carefully tests performance of newly-developed computer memory drum. Key to performance of navigational computer systems, the drum is able to store 358,000 bits of information in its baseball-size frame.

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Infinite life of the Sperry drum is achieved through use of an air-bearing suspension of the rotor instead of a conventional ball-bearing mounting. In addition, air bearings are immune to radiation which could clog the operation of ballbearings in space.

According to Sperry, the eight-pound aluminum spherical drum, which can store information at 600 bits to the inch, has six times the capacity of any unit its size. It can hold 358,000 bits of information. This capacity for retaining "knowledge" was achieved by using "floating heads" to pick up and record data. The heads "float" on a film of air one ten-thousandth of an inch above the drum's surface, instead of being fixed to the drum assembly as are standard heads.

Another feature of the drum is its so-called "one-word loop," which speeds computer performance by enabling it to utilize information virtually as fast as it receives it and deposits it on the drum. With more conventional equipment, a computer would have to wait for the drum to complete one revolution before "reading" the information it "wrote into" the cylinder.

Write No. 175 in Box on Inquiry Card

WORTH FILING

Molding Resins

Designed to provide designers and specifiers with a guide to the capabilities and application techniques of diallyl phthalate resins, a 26-page booklet examines the properties, uses, and molding requirements of compounds based on these resins. Thirteen tables give data on physical and electrical properties, chemical and fungus resistance, and flame proofing. One section deals with the effects of mineral and synthetic fillers on molded properties. Another deals with material handling, molds, molding temperatures and pressures, curing time, and tests for cure. A typical properties chart for molding compounds and a list of suppliers are also included.

Source: Food Machinery & Chemical Corp. New York, N. Y.

For your copy: Write No. 813 on Inquiry Card

SHOWN ¾ SIZE

WIDE ANGLE FLOATED RATE INTEGRATING GYRO FOR CONTROL APPLICATIONS

Designed for strapdown control applications, this miniature wide angle precision gyro provides accurate and reliable performance in extreme missile environments.

A newly developed high viscosity damping fluid with good low temperature characteristics permits large angular inputs without loss of reference and eliminates the need for paddle type damping devices. Low uncompensated drift levels are obtained through the use of externally controlled adjustments of mechanical mass unbalance and fixed torque drift. A unique torquer with external adjustments makes possible high torque linearity including at the "off null" position. The spin motor will operate satisfactorily from a three phase or single phase 400 cps power supply.

Actual test data taken on a group of these gyros demonstrate the capability of this device as the most accurate and stable control gyro now available. Typical test results include the following average values:

Uncompensated mass unbalance level—0.35°/hr/g avg.; Uncompensated restraint level—0.4°/hr avg.; Torquer linearity 0.017% avg. proportional from 0.1°/sec to 5°/sec.

TYPICAL CHARACTERISTICS

Angular momentum (gm cm²/sec.)		100,000
Operating temperature		180°F°
Torquer scale factor (°/hr/ma)		800
Input angle		Up to 30 degrees
Transfer function (mv/mr)		3.75 at gyro gain of 3.0
Dimensions:	**lengths**	3.56"
	body diameter	1.98"
	mounting diameter	2.15"
Weight		1.2 pounds

°lower operating temperature as required

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 13 ON INQUIRY CARD

HIGH-ACCURACY PRECISE ANGLE INDICATOR

NEW KEARFOTT UNIT ACCURATE TO ±6 MINUTES

The new CO 2721011 Precise Angle Indicator features an accuracy of ±6 minutes. Latest addition to the Kearfott line of standard test equipment, the unit is designed to meet a wide range of applications. Typical Applications • Indication of gyro angle of pitch, roll, or yaw and relaying of signal to any preselected impedance or voltage level. • Indication of shaft position of remote synchro or resolver, and transmission of this information to any impedance or voltage level. • Display of difference between two shafts when driven by transmitter and differential synchros.

In addition to high accuracy the instrument combines a number of other prominent advantages: it requires only a single power source; it has good sensitivity; it is designed for modular application; and it offers direct automatic read-out. The unit is of extremely compact construction and is built for maximal ease of maintenance.

The low-cost CO 2721011 Precise Angle Indicator is available with a single sensor, auxiliary dual-input sensor, or an auxiliary retransmitter. For additional information on this new test instrument, write for the brochure which describes its operation and capabilities in detail.

SPECIFICATIONS

Repeatability	±1.2 min	**Slewing Speed**	7 sec/180°
Readability	0.5 min	**Power (single source)**	115 v, 1φ, 400 cps
Input Power	30 va	**Size**	1¾ x 9½ x 9⅛ in.
Sensitivity	1.0 min	**Weight**	4 lbs.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 14 ON INQUIRY CARD

SPECIAL PURPOSE PRECISION BEARINGS FROM KEARFOTT

Highest quality, special purpose precision bearings are now available from Kearfott Division, General Precision, Inc. for military and industrial applications requiring utmost reliability, accuracy and stable performance. Over 10 years of research, testing and development have gone into the production of these outstandingly reliable, precision bearings.

Designed to meet the most exacting systems standards, these special purpose precision bearings have more than passed the test of time, delivering long life performance for Kearfott gyros, instruments and other critical airborne equipment. Engineering and technical excellence derived from long experience enables Kearfott to ensure delivery of bearings that provide unsurpassed qualities of roundness, concentricity, curvatures, finish, dimensions and functional tolerance.

Special purpose, high precision bearings from 0.3125 to 4.5 inches O.D. are now ready for production delivery in a wide range of application types including—

- **SEPARABLE TYPE BEARINGS for gyro spin axes**
- **STABLE PLATFORM GIMBALS**
- **GYRO PRECESSION AXES**
- **OTHER SPECIALIZED, HIGH PRECISION bearing applications**

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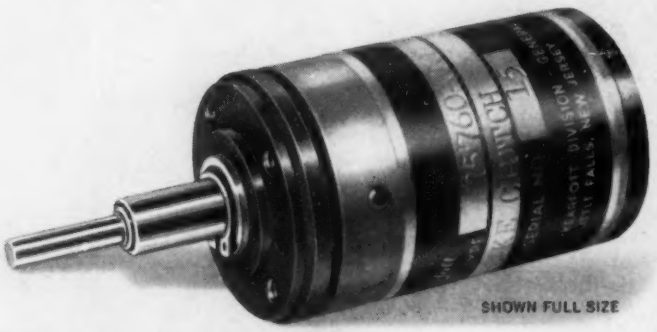
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 15 ON INQUIRY CARD



MINIATURE, HIGH PERFORMANCE MAGNETIC BRAKES AND CLUTCHES

Typical applications involving these Size 11 magnetic clutches, brake clutches, and brakes include service as output controls in mechanical differential computers, as motor brakes, and as speed changers and uncouplers. Kearfott can also provide magnetic clutches, brake clutches and brakes in various other sizes to suit desired applications. Components also available in sizes 8 and 6 diameters.

CHARACTERISTICS

	Magnetic Clutches		Magnetic Brake Clutch	Magnetic Brake
Unit No.	**R5750-001**	**R5750-002**	**R5760-001**	**R5770-001**
Size	11	11	11	11
Power input (Watts)	3	3	3	3
Clutch Torque (In. Oz.)	6 (energized)		4 (energized)	–
Brake Torque (In. Oz.)	–	–	6 (de-energized)	16 (energized)
Inertia (gm cm²)	.82 (energized) .56 (de-energized)		.82 (energized) .56 (de-energized)	.34
Engaging Surfaces	Steel	Brake Material	Steel and Brake Material	Steel
Environmental Performance	Per MIL-E-5272A			
Life (Cycles)*	3,000,000			

*1 Cycle=1 revolution of shaft engaged and 1 revolution of shaft disengaged, at 500 RPM.

Write for complete data

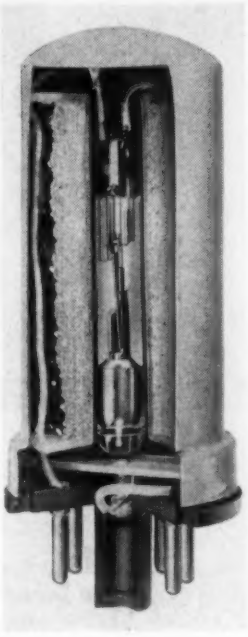
KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 16 ON INQUIRY CARD

MERCURY-WETTED CONTACT RELAY

High Speed Unit Free From Contact Bounce



Mercury-wetted contact relays designed to give over a billion reliable operations with complete freedom from contact bounce are being developed by the Automatic Electric Co., of Northlake, Ill. Particularly adaptable to computers, data-processing equipment and in machine tool applications, the high-speed relay requires no maintenance and is capable of high power or low level operation.

The relay consists of a contact assembly mounted and sealed in a glass capsule, an operating coil, and a steel housing with an 8-pin octal plug. The switch capsule is enclosed by the coil and thus is located in the magnetic field set up by the coil.

Contact and armature assemblies are hermetically sealed in a glass capsule with a hydrogen atmosphere under high pressure. At the base of the capsule is a small pool of triple-distilled mercury. Two parallel wires that are formed into a T-shaped moving contact provide a capillary path for the mercury. The murcury is fed from the pool to the contact area by capillary action, continuously wetting and renewing the contacts.

Action of the mercury-wetted contacts is entirely different from that of conventional metallic contacts. When the armature contact moves away from the break contacts, it draws a filament of mercury with it, producing a make-before-break (form D) action. The mercury effectively masks any slight rebound of the metallic contacts on closing and the electrical circuit is maintained without interruption. Also, contacts exhibit no wear or erosion and welding or sticking is completely eliminated.

Minimum operating time of the single capsule relay is 3 milliseconds with a coil input of approximately 2 watts. Release time is about 3 to 3½ milliseconds under all conditions of coil input power. The switch capsule can be driven at speeds up to 100 operations per second. The relay will switch 250 volt-ampere loads with a maximum of 5 amps, 500 volts and has an operation sensitivity of 250 milliwatts, minimum. Unit is 1.105" in diameter and 3.196" high and its net weight is 4 oz.

Write No. 158 in Box on Inquiry Card

"Forget it, McClenahan! There's no money in Anti-gravity."

WORTH FILING

Hydrogen Thyratrons

Theory and application of hydrogen thyratrons is comprehensively discussed in a 20 page bulletin. Schematics, graphs and charts detail the construction, operation, applications, and characteristics of hydrogen thyratrons. Technical descriptions and data for 3 different tubes are also included.

Source: General Electric Co.
Schenectady, N.Y.
For Your Copy: Write No. 821 on Inquiry Card

Beryllium Copper

The many advantages of using beryllium copper, its physical and mechanical properties and how to select the right beryllium copper alloy to meet specification requirements, are explained in a 12 page bulletin. Five alloys are presented in tabular form with complete data on properties before and after heat treatment. Also provided are properties in annealed, quarter hard, half hard, and hard state.

Source: The Beryllium Corp.
Reading, Pa.
For Your Copy: Write No. 818 on Inquiry Card

Precious Metal Contacts

Detailed study of precious metal electrical contacts, their applications and selection criteria is included in a technical bulletin together with other articles on thermocouple materials, problems posed by radioactivity in refining precious metal scrap, and abstracts of recently issued U. S. patents concerning precious metals. The lead article discusses electrical and mechanical applications of precious metal contacts, the environment in which they are to operate, and the contact material itself.

Source: Engelhard Industries, Inc.
Newark, N. J.
For your copy: Write No. 822 on Inquiry Card

Instrument Bearing

Containing all data necessary for selecting and specifying ball bearings for modern instruments, a 40-page catalog contains dimensional information as well as the practical engineering and application data required to service this highly specialized field. A unique feature of catalog is its picturing of bearings' actual sizes. Catalog enables designers to select ball bearings which offer practical and economical solutions to application problems.

Source: The Fafnir Bearing Co,
New Britain, Conn.
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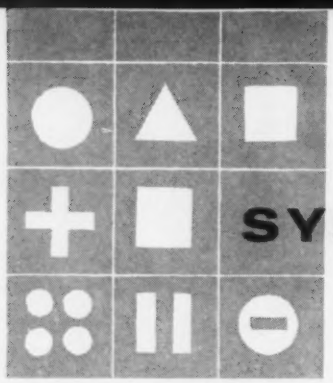


SYSTEMS DESIGN

PAPER-TO-MAGNETIC TAPE CONVERTER

D. K. Close, Staff Engr.
L. W. George, Associate Engr.
R. E. McGayhey, Dev. Engr.
E. A. Wheeler, Staff Engr.

Prod. Dev. Lab., IBM Data Systems Div., Poughkeepsie, N.Y.

For direct and much faster computer input, IBM Corp. has developed the 7765 Paper Tape to Magnetic Tape Converter that transcribes at a rate of 150 characters per second. This "off line" conversion operation essentially makes possible the entering of paper tape information into computing systems by 200 bits-per-inch magnetic tape.

Applying standard modular packaging techniques, engineers at IBM designed the paper tape reader and the magnetic tape writer so that they can be used as components with other systems as well as the 7765. High on the list of "must" items, in design of the converter, were use of solid state circuitry throughout the system, and packaging to achieve most efficient serviceability.

The paper tape reader features chad (fully perforated) and chadless (partially perforated) reading, center roll, strip and reel feeding with simplified reel controls. The magnetic tape writer features character by character (incremental) writing on a demand basis and semi-automatic tape loading.

DESIGN OF PAPER TAPE READER

Since there is a large volume of chadless telegraphic code paper tape and terminal equipment already in existence, a main objective was to have the device read chadless (partially punched) paper tape at high speed. The reading head is shown in Fig 1. Pin sense methods of reading are speed limited since pins act very much like punches at high speed. Since photosense techniques are very adequate for chad tape reading it was decided to use the same method on chadless reading. However, a reliable method of opening the tape flaps for "peek through" sensing had to be found. The result involved running the tape around an outside radius to open the flaps and locating the read photocells at the "flaps open" point. To open the flaps reliably meant that tension of the tape as it rounded the bend in the head had to be kept tight. This was accomplished by using sprocket hole feeding in a trapped loop under tension around the head area.

Photosensing elements had to be reliable, temperature insensitive and meet the space requirements of the flap opening read head. Texas Instruments' IN 2175 silicon photo duo diode was selected as the basic sensing element. In order to sample the coded holes at proper time, it was decided to get the sample pulse from a perforated disk located on the pin wheel shaft instead of reading feed holes (disk perforations are read photoelectrically). Two reasons prompted this decision:

- Some equipment "pierce" feed holes rather than punching them, resulting in an opening difficult to read reliably.
- In punching tape, the feed hole is punched for every column. This punch wears more rapidly than the code hole punches. Thus, fuzzy hole punching shows up first on this smaller diameter feed hole making it the most critical for reading. To further enhance reading reliability, the reader was designed to gate in the code holes for the full duration of the disk hole sample time.

In addition to strip feeding and reel feeding, a high speed center roll feed device was designed. Normal winding of tape on reels results in the leading edge (beginning of data) on the inside. Rewinding is necessary to orientate the leading edge to the outside for reel feeding. The center roll feed device allows feeding of the tape from the center of the roll, eliminating the rewind operation.

Major problems in the design of the center roll feed were:

- Difference in weight of small and large rolls.
- Difference in tightness of a roll of chad tape as compared to chadless. (Chadless does not wind tight due to the partially punched chads or flaps.)
- Desirability of a horizontal feed arrangement since a roll does not have a reel hub while being center fed.
- Differences in record length from one job to another.

Most of these problems were solved by use of a free turning horizontal turntable with a fixed center (Fig 2). As tape is pulled from the center, the

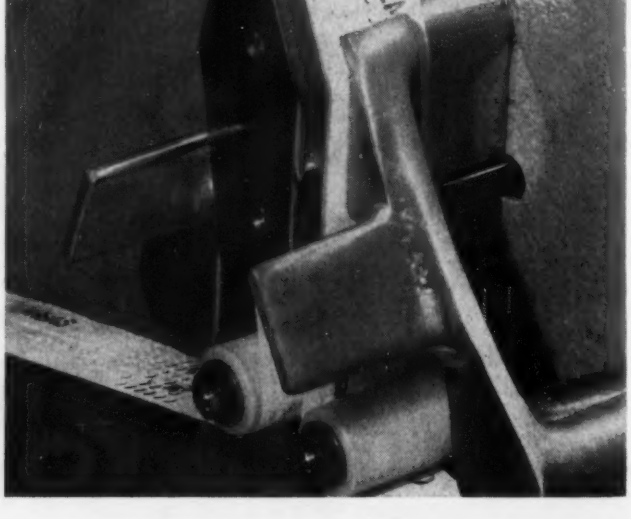


Fig 1 Paper tape reader head.

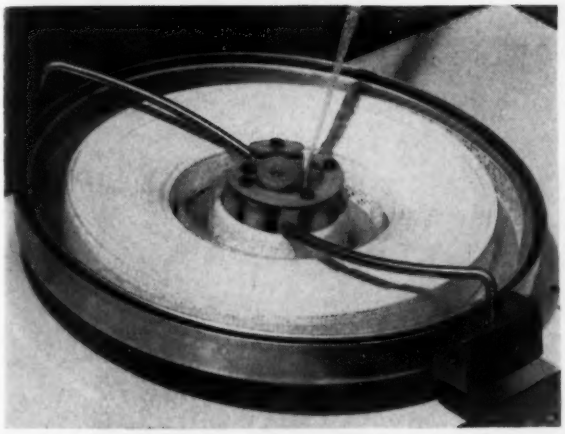


Fig 2 Paper tape center roll feed

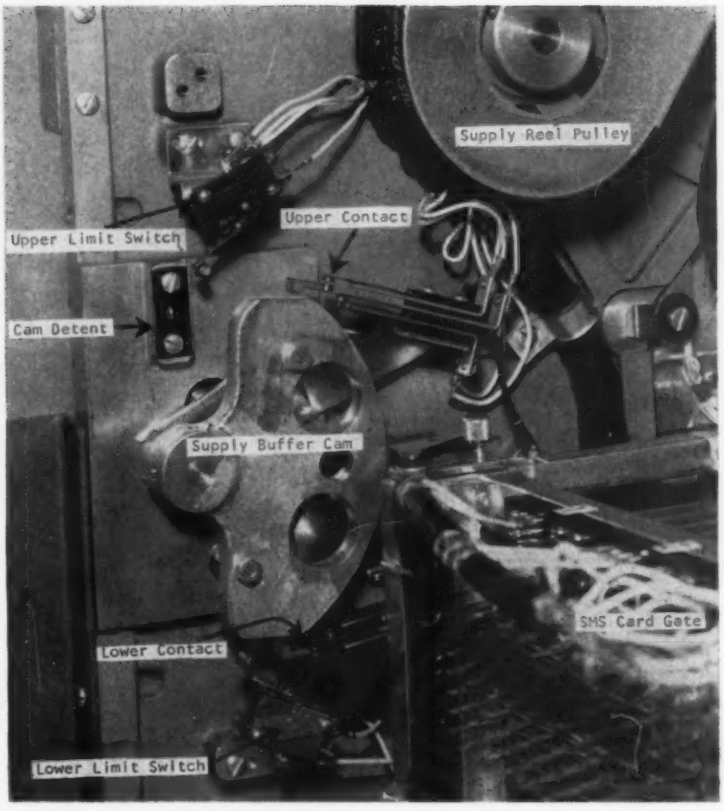


Fig 3 Reel control system of the paper tape reader. Start-stop points are determined by contacts operated by a cam mounted on the reel buffer arms. Reel stopping is controlled by dynamic braking. The start-stop points are duplicated to allow reel motion in either direction.

sliding movement of the turns of the roll causes the turntable to start turning slowly. As tape continues to be drawn out, the turntable moves faster and then acts as a supply reel due to its momentum and low friction bearing mount. A simple feedback arrangement solved the problem of stopping the turntable when tape is no longer required. The turntable was modified to include a mechanical detent for stopping. The detent pawl was then linked to a tension roller in the center. Thus, when tape slack develops, the detent goes into position and stops the turntable within one revolution.

Using dc motors on a start-stop basis, a simplified reel control system was designed. This control system is described in Fig 3. The drive system for the paper tape reader is described in Fig 4.

DESIGN OF MAGNETIC TAPE WRITER

The incremental-step-by-step-approach with 200 bits per inch spacing 0.005 inch, used in the magnetic tape writer, enables demand and response writing and eliminates the need for speed buffer registers which are needed on synchronous tape drives. In an attempt to engineer a low-cost, accurate incrementing device, several methods were investigated. Ratchet type, magnet-controlled methods did not prove suitable because of mechanical wear and difficulty in obtaining accurate increments. Electrostatic clutch devices were rejected because of temperature and humidity variations. The selected method was the stepping motor approach. The stepping motor was low cost, reliable, quiet operating, and gave accurate incrementing beyond the ⅞ inch/second (175 cps) speed range. It was not affected by temperature or humidity and wear was no problem.

The stepping motor moves 18 degrees per step while the tape drive capstan must move 1.25 degrees per step, thus, some form of reduction was necessary. Gears were discarded due to excessive wear, inertia, and drag. Miniature timing belts were used because of low inertia and drag, along with quiet operation.

IBM's 729 write head was used as the magnetic tape write unit. Since other systems using the magnetic tape unit require reading as well as writing, a method of static reading had to be developed. The read head reluctance is changed electromagnetically with an ac current signal. The presence of a bit

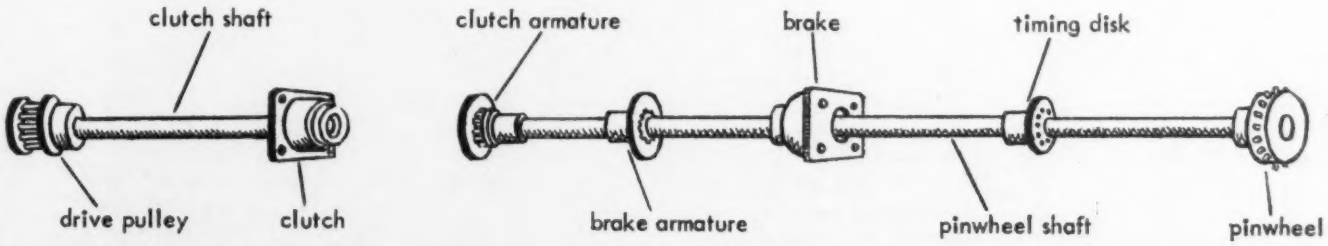


Fig 4 Paper tape drive system. Use of sprocket hole guiding (necessary for chadless trapped-loop operation) meant that starting and stopping by tape pinch techniques could not be used. A search was made for a reliable method of quickly starting and stopping the higher masses inherent in the sprocket wheel, sampling disk and shaft. The result was a magnetic brake and clutch arrangement. At a tape speed of 15 inches per second, the paper tape is stopped prior to reading the code following the stop code. When used with the 7765 converter, however, a readout register is used that has the ability to store a single character at stop time.

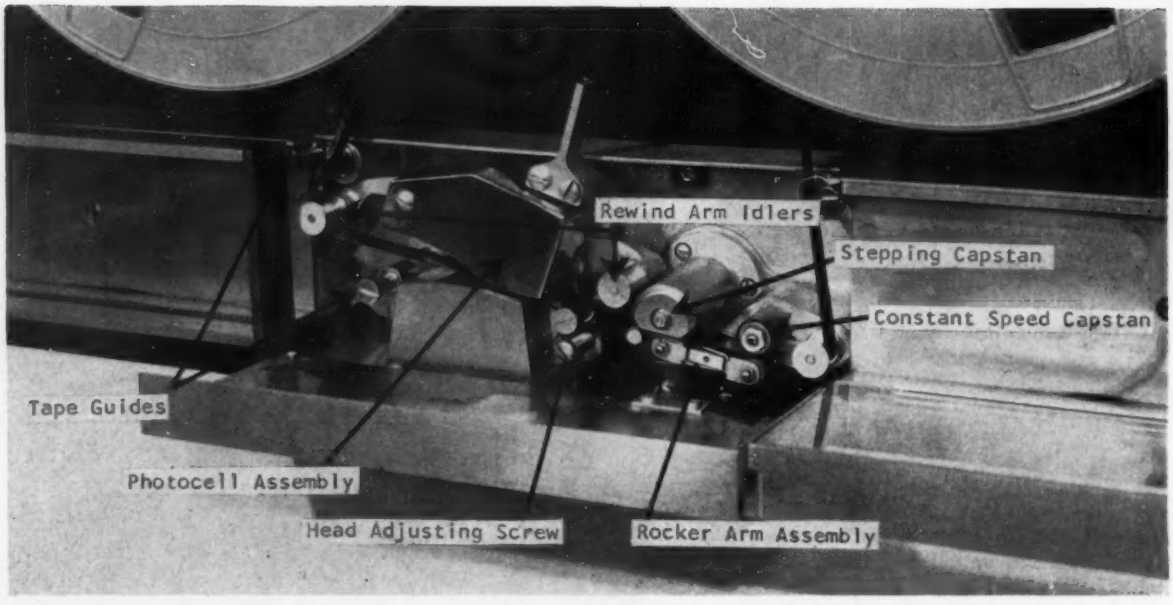


Fig 5 Magnetic tape transport, columns and reels. For easy service, the write head and tape guides are mounted on a single plate which can be inserted or removed as a separate assembly. The low ratio of operator loading time to magnetic tape reel loading time made it feasible to provide semi-automatic tape loading. This was done without materially affecting user's operating time.

at the read head will cause flux to flow through the read head at a frequency determined by the ac current signal. This change of flux produces a voltage on a winding which is then amplified.

To improve machine efficiency during writing of record gaps, a 15 inch per second speed drive was designed. At "gap" time, control is changed from a low-speed drive capstan to a high-speed capstan by means of a rocker arm. Slow-speed rewind is accomplished by running this same capstan in the reverse direction.

Since a single 15 inch per second capstan moves tape in both directions, one of the problems was to keep friction in the tape path to a minimum and insure that there was sufficient force to pull tape back over the head and guides. The tape is pulled back by action of the supply reel vacuum column. The tape transport assembly is shown in Fig 5.

For low cost and simple control, dc shunt wound motors were used to drive the supply reel and the takeup reel. A magnetic brake disk was used to positively stop the motor and reel more. DC motors are also used for a 100 inch per second rewind operation with the supply motor dynamically braked to provide correct tape tension, pulling tape and the take-up reel.

To isolate the reels from the tape capstan for inertia reduction purposes,

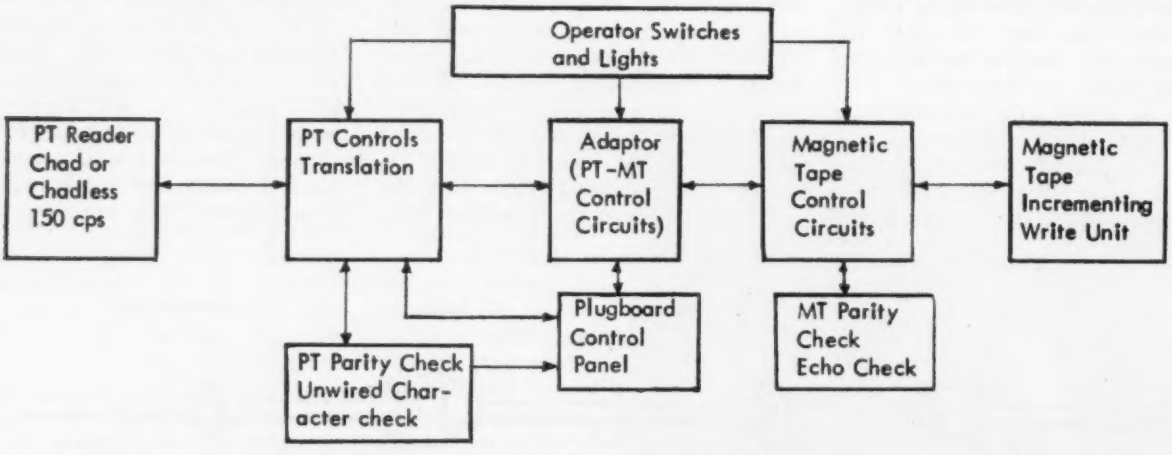

Operator Switches and Lights
PT Reader Chad or Chadless 150 cps
PT Controls Translation
Adaptor (PT-MT Control Circuits)
Magnetic Tape Control Circuits
Magnetic Tape Incrementing Write Unit
Plugboard Control Panel
MT Parity Check Echo Check
PT Parity Check Unwired Character check

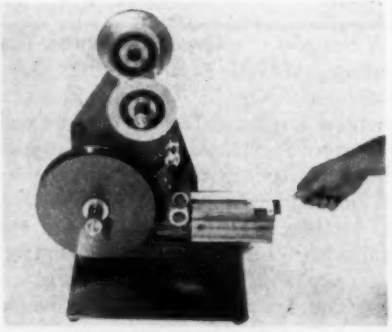
Fig 6 Logic flow diagram of the IBM 7765 PT-MT Converter. In addition to conventional paper tape and magnetic tape parity checking the following machine checks are made. Demand response — when a character is delivered by the reader a check is made to insure that the magnetic tape write unit has written and responded before the next paper tape character is sent. Stopping limit — a check is made to detect if the reader is exceeding its stopping specs. On the 150 cps reader, a check is made to insure that the reader does not go by the first character past the stop character. Sync disk — at 150 cps, when up to speed, a sync disk signal should occur every 6.7 milliseconds. Single shot timing circuits energized by the sync disk are used to check for proper operation of the sync disk and its associated circuitry. Photocell check — a check is made when the machine is turned on and after each paper tape runout to insure that all code hole photocells and sensing circuits are operating correctly.

vacuum columns were used. Due to the lower speeds, the vacuum columns could be shorter than those used on the standard 729 write head, and could be placed in a horizontal rather than vertical position. This met the requirements of compact packaging and lower cost.

Figure 6 is a logic flow diagram of the converter. Use of the incrementing magnetic tape writer eliminated the need for speed buffering registers by allowing character by character conversion on a demand and response basis. All functions and translations are controlled through control panel wiring. In operation, paper tape information is gated into the magnetic tape writing unit to cause:

- Writing and echo checking of the character.
- A 0.005 inch magnetic tape step in preparation to writing the next character.

Write No. 159 in Box on Inquiry Card



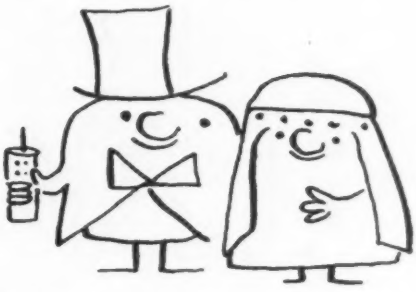
INSULATION LAMINATOR

Designed to make any electrical insulation pressure-sensitive right on the production line, an insulation laminator, developed by Minnesota Mining & Mfg. Co., St. Paul, Minn., uses a recently designed polyester film tape which is located on both sides with a thermosetting, pressure sensitive adhesive. The laminator contains feed spools for the double-coated tape and the insulating material, with a take-up spool for the tape separation liner. The tape and insulation are laminated together as they are removed from the dispenser.

With the added efficiency of the laminator-dispenser, many jobs which previously required two or more pieces of tape, or time-consuming adhesive applications, can now be completed in one operation. Minnesota Mining & Mfg. Co., St. Paul Minn.

Write No. 552 in Box on Inquiry Card

A dizzy young bride named Sue Lots
Went shopping one day for some pots
"The best in the house
"None too good for my spouse"
Now the Lots own Electro-Mec pots!



Even if you can't use them for cooking
Your design will be better
with **Electro-Mec Potentiometers***.

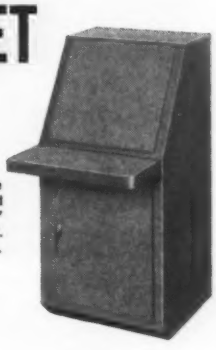
*Write for data sheets and further information about our complete line of SUPERPRECISION potentiometers. Certified calibration data, including recordings of output function are supplied with each instrument. If RELIABILITY is your goal, always specify ELECTRO-MEC potentiometers.

ELECTRO-MEC *Division of WALTHAM Precision Instrument Company, Inc.*
47-51 33RD STREET, LONG ISLAND CITY 1, N.Y.

CIRCLE NO. 17 ON INQUIRY CARD

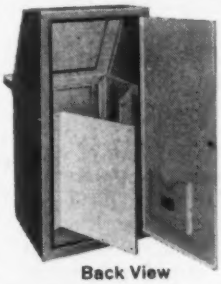
Newest and most advanced

MULTIPLE-USE
CONSOLE CABINET
OIL-TIGHT and DUST-TIGHT



Made of 14 gauge steel with welded seams. Height 50" width 24", depth 23". Writing desk optional.

WITH WIDE APPLICATIONS IN BOTH ELECTRICAL AND ELECTRONIC FIELDS



Back View

This Hoffman Model 14 heavy-duty oil-tight console enclosure is designed as an operator control station with maximum flexibility to meet variable needs. The sloping front panel is ideal for mounting meters, switches and pushbuttons.

Flush key-locking gasketed doors, front and rear, provide access to lower sub-panels which can be either stationary or swing-out. Note provision for pull-out electronic chassis and rack panels if desired, or combination stationary panel with pull-out chassis. This is the most versatile, heavy duty, all-welded oil tight and dust tight cabinet available today! Write immediately for Bulletin 139.

Hoffman **ENGINEERING CORPORATION**
Dept. EMD-171 • Anoka, Minnesota

CIRCLE NO. 18 ON INQUIRY CARD

SYSTEMS DESIGN

DATA STORAGE

Access To 600 Million Bits In 167 Milliseconds

Combining the reliability and fast access of magnetic drum memories with the high capacity and low cost of magnetic tape memories, Bryant Computer Prods. Div. of Ex-Cell-O Corp., Walled Lake, Mich., has developed mass memory disc files ranging in capacity from 30 million to 600 million bits of information, and with a maximum access time of 167 milliseconds, including 100 milliseconds for positioning. Average access time excluding positioning is 34 milliseconds. Cost per bit ranges from one-tenth of a cent in the smallest unit to one-fortieth of a cent in the largest.

The Bryant disc files are precision electromechanical devices, in which information is stored in magnetic code on a number of vertical discs. "Reading" and "writing" of information are accomplished by air-floated transducers which scan the sides of the discs. The file can read and write either a line-at-a-time or a character-at-a-time. Of modular construction, incorporating from one to 20 discs, the memory files use a common base structure and a common drive system housed in a centralized pedestal mounted on the base. The discs are mounted on interchangeable precision spindles of the length required for the number of discs designed in a unit. Rotational speeds of 900-1200 rpm are standard.

"Reading" and "writing" on each disc face is accomplished by six magnetic heads mounted on a rocker arm which is movable to permit each head to serve 128 tracks. All of the rocker arms are locked together for movement as a unit under control of a digital actuator. The actuator is an open loop, hydraulic system capable of moving the heads to any one of 128 positions with an accuracy of better than 0.005 inches. Positioning is accomplished in less than one-tenth of a second in response to seven binary address signals. Positioning accuracy is guaranteed for the life of the file.

Write No. 230 in Box on Inquiry Card

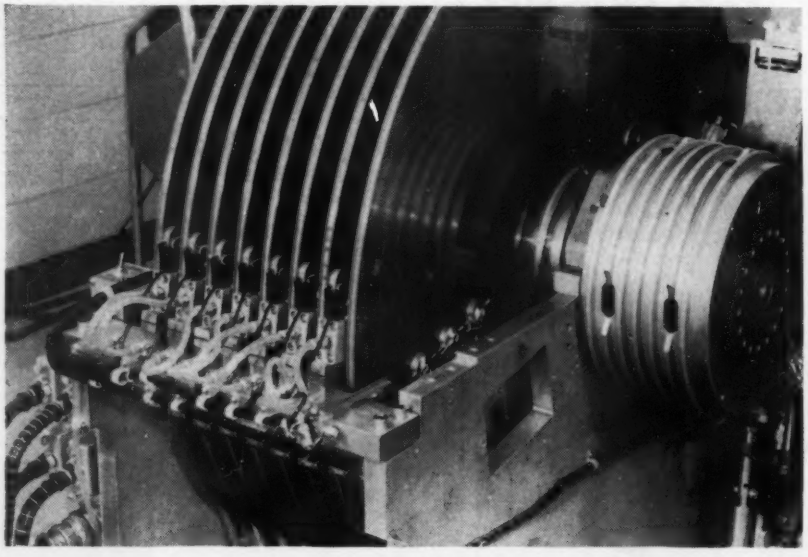


Fig 1 Close-up view of discs and magnetic heads of Bryant Computer Prods.'s memory disc file. Simultaneous positioning of all heads makes parallel "reading" and "writing" with a number of heads an inherent capability. Clock tracks time reading and writing accurately, thus permitting selective alteration of recorded information. A single set of six clock tracks is normally provided for the entire disc file, with one track for each of the six heads per disc side. Recording frequencies ranging from 174 kc in the innermost tracks of a disc to 431 kc in the outermost tracks, based upon a maximum pulse packing of 273 bits per inch, are standard. Additional clock tracks and sector address tracks are available to suit individual requirements. Recording surfaces are of hard magnetic oxide, micro-finished to insure recovery of all recorded information, and to maintain a normal signal-to-noise ratio of 40 to 1 (32 Db). Read and write circuitry, head switching, and clock circuits are completely transistorized and modularly packaged to facilitate build-up of systems meeting special needs for serial, parallel and serial-parallel recording capability. Additional system flexibility is achieved by incorporating multiple, individually-addressable actuators, each controlling the position of a group of heads, or by including a second set of heads, serving the same tracks and positioned by an independent actuator.

MULTI-PROCESSING COMPUTER

Advances in Man-Machine Communication Result in a more Efficient Use of High-Speed Capabilities

Departing from traditional concepts of electronic computer design, Burroughs Corp., Detroit, Mich., developed a new solid-state electronic information processing system that makes flexible multiprocessing and system expansion without reprogramming practical for the first time.

From the beginning, automatic programming experts, top systems analysts and design engineers worked together to design the B5000. Basic to this approach was that hardware and "software" – automatic programming and operating systems – must not only be developed concurrently, but that the software should help dictate equipment specifications. The result was a problem-oriented system, operating in common algebraic and business languages, so that high-speed computations would no longer be preceded by painfully slow computer programming, problem translation and debugging.

A complete "software" package – including ALGOL (Algorithmic Language and) COBOL (Common Business Oriented Language) compilers, as well as powerful extensions of each, and a comprehensive master control program– will be standard with each system. This will enable users to communicate efficiently with the machine in the language of the problem, both for initial programming and subsequent symbolic debugging, rather than in complex numerical codes. Efficient object machine language programs will be compiled automatically 20 to 50 times faster than the most advanced automatic programming techniques employed thus far on conventional computers, the Burroughs president declared.

Conventional computers that have some multi-processing control facilities permit more than one program to be operated upon a "time-share" provision, but only if the same programs are always processed together or manually re-sequenced. The B5000 eliminates this requirement by allowing machine programs to be "floated" or relocated. New programs and/or segments are fitted into memory and executed regardless of program additions or deletions. The system can be expanded or contracted without reprogramming through a new concept of program-independent modularity.

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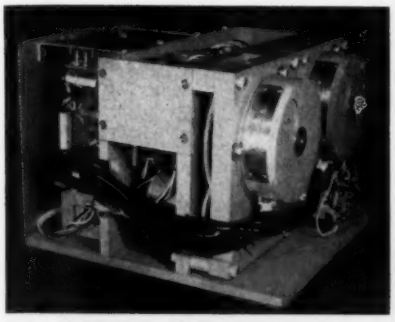

Servo Repeater System

When used with appropriate synchro-transmitters, a two-speed servo repeater system provides digital coded contact closures corresponding to the angular position of a remote shaft. The integral package contains two control transformers, a servo-motor, synchro-switch, servo-amplifier, two shaft position encoders, and interconnecting gear trains. Coded output enters via storage and translation circuitry into recording devices such as printers, tape punches, card punches, and lamp banks. Supplying the coded output, encoders contain up to 1024 quanta per 360° revolution. Datex Corp., Monrovia, Calif.

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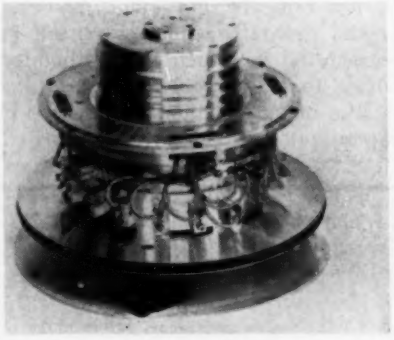

Magnetic Drum Sub-System

Having a safety system for achieving constant accurate head-to-drum spacing, a magnetic drum assembly has been described as a light weight, high bit storage capacity, low cost buffer memory unit. It consists of drum, heads and read-write circuitry. The basic 5" drum weighs less than 22 lbs and rotates at 8,000 rpm. Complete assembly fits into an enclosure 10" wide by 7½" high. Maximum drum capacity is 50 tracks with recirculating registers operating as close as 10 bits. Requiring no gauges, unit precludes errors due to deflection of gauge holders, and transfer of measurement. Sub-system also offers a quick way to test various head characteristics. General Instrument Corp., Los Angeles, Calif.

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RESOLVER NEWS!

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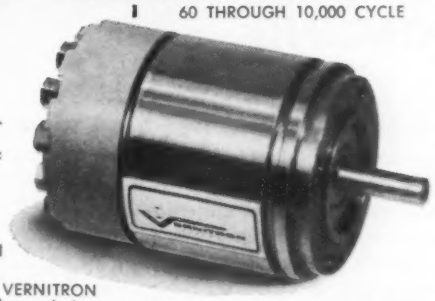

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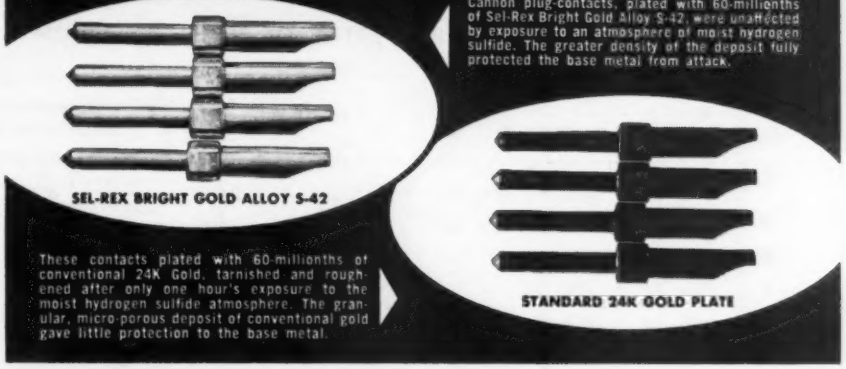
CIRCLE NO. 20 ON INQUIRY CARD

CANNON ELECTRIC improves contact performance with SEL-REX Bright Gold Alloy S-42


Cannon plug-contacts, plated with 60-millionths of Sel-Rex Bright Gold Alloy S-42, were unaffected by exposure to an atmosphere of moist hydrogen sulfide. The greater density of the deposit fully protected the base metal from attack.
SEL-REX BRIGHT GOLD ALLOY S-42
These contacts plated with 60-millionths of conventional 24K Gold, tarnished and roughened after only one hour's exposure to the moist hydrogen sulfide atmosphere. The granular, micro-porous deposit of conventional gold gave little protection to the base metal.
STANDARD 24K GOLD PLATE

Contacts used in world-famous Cannon Plugs must be capable of withstanding corrosion and tarnish, in addition to the punishing effects of repeated engagement and disengagement. The photographs, taken by Cannon in their own laboratory, show why conventional 24K gold plate failed to meet the requirements of this application.

Both samples were plated with 60-millionths of gold over silver plate, and were photographed after an hour's exposure to an atmosphere of moist hydrogen sulfide. The contacts plated with 24K gold tarnished and roughened—those plated with Sel-Rex Bright Gold Alloy S-42 retained their original mirror-bright finish.

Says Cannon, "At Cannon Electric, Sel-Rex Bright Gold Alloy S-42 has been instrumental in solving wear and tarnish problems encountered in connectors used in aircraft, and intricate missile and electronic components."

The foregoing is just another of our many case histories which prove that: "From Missiles and Rockets to Misses and Lockets—there's a Sel-Rex Precious Metal Plating Process to help you make your product better, more salable."

For other case histories, technical information and application data, ask for ML-1.

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CIRCLE NO. 21 ON INQUIRY CARD

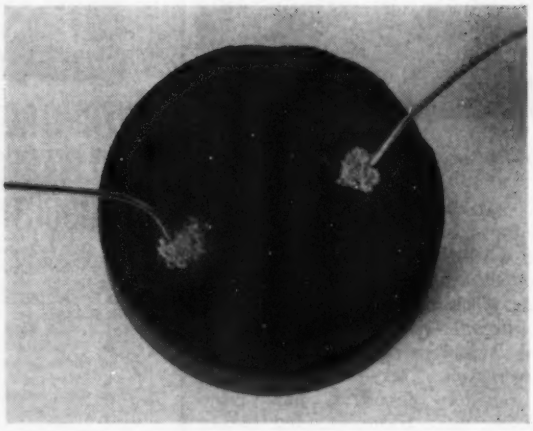
LOW-TEMPERATURE BONDING

Dental-type-gallium alloys bond wires to heat-sensitive electronic devices.

Gallium-based alloys are soft when mixed at room temperature, but resist temperatures as high as 900° after hardening. In a study project sponsored by the Air Force, the National Bureau of Standards has found that these alloys can be used to fasten wires to heat-sensitive electronic devices, such as transistors, and to "cold solder" ceramic and metallic surfaces.

Like mercury, gallium combines with many metals to form dental-type alloys which harden after from 2 to 24 hours. To form these alloys, weighed portions of liquid gallium (mp 29.9°C) and a finely powdered metal are thoroughly mixed in a Teflon beaker. After several minutes mixing, during which the gallium "wets" the other metal, the alloy is ready for use.

Various combinations of gallium with copper, gold, nickel and silver were prepared and tested in this program. Addition of tin to several of the gallium-copper alloys delayed the initial set. Practical batches as small as 0.1 gram were sufficient to attach several electrodes to a surface. The Bureau found that unused portions of gallium-gold alloys could be preserved for later use if refrigerated before hardening had occurred.



A gallium-gold alloy was used to fasten wires to a small, electrically conductive ferrite specimen. These alloys, investigated by the National Bureau of Standards, are soft when mixed at room temperature, and resist temperatures to 500°C after hardening.

Expansion tests on various gallium alloys indicated that as much as 10 percent expansion may occur during hardening. This expansion is not critically important, however, since the soft-packed metal generally compresses itself instead of damaging the material in which it is imbedded. Addition of alumium oxide to gallium-gold alloys resulted in better bonding in cavities of barium titanate, perhaps by reducing the thermal expansion of the mixture.

PROPERTIES OF SEVERAL GALLIUM ALLOYS.

	Constituents in weight %	Approx. hardening times at 25°C	Maximum useful temperature in air	Expansion coefficients and remarks
1.	44% Cu + 24% Sn, 32% Ga	24 hr	650°C	$\alpha = 23.7 \times 10^{-6}$/°C after heating
2.	50% Cu + 18% Sn, 32% Ga	24 hr	700°C	$\alpha = 23.1 \times 10^{-6}$/°C after heating
3.	66% Cu + 34% Ga	4 hr	900°C	$\alpha = 19.5 \times 10^{-6}$/°C after heating
4.	82% Au + 18% Ga	5 hr	450°C	...
5.	66% Au + 34% Ga	8 hr	525°C	$\alpha = (15 + 0.012T)\ 10^{-4}$/°C
6.	59% Au + 41% Ga	8 hr	475°C	...
7.	33% Au + 33% Cu + 33% Ga	8 hr	650°C	...
8.	49% Au + 21% Ag + 30% Ga	2 hr	425°C	...
9.	65% Ni + 35% Ga	48 hr	250°C	Becomes a black powdery mass above this temperature
10.	52% Ag + 48% Hg	3 hr	900°C	Contracts while hardening
11.	Au, Ag, Co, Cu, Ni, Sn	These metals and possibly many others may be added in varying amounts to the gallium alloys to change the setup time and/or the thermal expansion		

All of these alloys, except No. 10, expand as they harden, thus locking themselves into the semiconductor cavity.
Hardening-time values assume a particle size to pass through a 300 mesh screen. Larger particle sizes may take longer. Setup times at higher temperatures will be considerably less. Five or ten minutes will usually suffice at 200° C. At this temperature the Au-Ga mixture produces an exothermic reaction.
Actual melting point is about 25° C higher than the maximum useful temperatures given. These temperatures are only reproducible to ± 15° C because some of the fine metal powder usually sticks to the mortar or is not properly wet by the gallium.

INLAND

first with solid state 100-watt d-c amplifier

Inland's new **Model 579.35** d-c amplifier has a high power output of 100 watts when used with low impedance loads requiring direct current. And this completely transistorized amplifier is packaged in a hermetically sealed can only **2½" x 3⅜" x 2½".**

Designed for use with d-c torquers, in one typical application Model 579.35 provides 65 db power gain between the output of a d-c driver stage and the input terminals of a permanent magnet torque motor. This amplifier has these outstanding performance characteristics:

- The d-c output has magnitude and polarity proportional to the input signal.
- All amplifier circuits use a combination of silicon and germanium transistors (all-silicon models also available).
- Amplifier null and gain are stable and independent of temperature.

Inland also makes a complete line of rotary amplifiers for matched use with Inland's distinctive pancake shape d-c torquers.

A brochure on this new high-power amplifier is available. For your copy and complete data on Inland torquers and amplifiers, write Dept. 4-4.

TYPICAL SPECIFICATIONS

Maximum Power Output, watts (6 ohm load)	100
Power Gain	4,000,000
Current Gain	200,000
Voltage Gain	15
Frequency Response	DC to 1000 cps
Input Impedance, ohms	50,000
Dimensions, inches	2½ wide 3 3/16 long 2½ high
Operating Temperature Range in °C	minus 50° to plus 50°

INLAND MOTOR

INLAND MOTOR CORPORATION OF VIRGINIA • A SUBSIDIARY OF KOLLMORGEN CORP., NORTHAMPTON, MASS.

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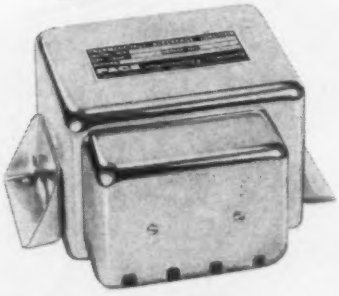
PACE

PRECISION IN-FLIGHT REFERENCE JUNCTION

WITH ±1/5°F STABILITY

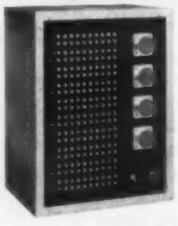
Solid state, bridge stabilized control provides a precise temperature reference for multichannel thermocouple systems with minimum space, weight and power consumption.

Series FRJ In-Flight Reference Junctions



PACE Series FRJ miniature, In-Flight Thermocouple Reference Junctions are designed for operation on 115 volts, 400 cps. They meet or exceed MIL-E-5272 for Acceleration, Vibration, Altitude and Humidity. Available with up to 24 channels and any reference temperature from 25°F above ambient to 250°F, the new instruments weigh only 2 lbs.

Series BRJ Reference Junctions



For extreme precision in laboratory and ground test applications, PACE builds the BRJ Series Thermocouple Reference Junctions, operating from the 115 volt, 60 cycle line. Temperature Stability and Uniformity for long term unattended operation are within ±1/10°F.

Write today for detailed Reference Junction information. PACE also builds AC and DC Pressure Transducers, Telemetering Equipment and Instrumentation Systems.

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TECHNIQUES

APPLICATIONS

The soft alloy is readily used to fasten wires to various devices. As an example, a gold-gallium-tin alloy was used to attach thermocouples to power transistors. Small holes were drilled in the transistor to receive the wires. Fine wires were then inserted in the holes, and the alloy was packed in with dental tools. After a period of hardening, the connection was ready for use. Wires that react with gallium, such as gold, cannot be fastened by this process because they become brittle and snap. For best results, the wires should be between 0.01 and 0.03 inch in diameter.

The alloys can also be used to cold solder various materials. This process once again offers the advantages of low-temperature formation and high-temperature strength. Pieces to be fastened together are positioned with a layer of alloy sandwiched between, and pressure is applied until the alloy has hardened. If no reaction occurs between the alloys and the materials being joined the bond is purely mechanical, and the bond strength depends upon the roughness of the surfaces involved. With some materials, such as copper, a reaction may occur between the alloy and the pieces being joined, resulting in a stronger bond.

By using higher formation temperatures, cold soldering may be extended to include a wide variety of metals and alloys. For example, a finely-powdered mixture of indium and gold could be placed between the surfaces to be joined, and the whole assembly heated until the indium melts. At this temperature an alloy would be formed with the gold, which, after hardening under pressure, would form a joint that could withstand a much higher temperature than the indium metal alone. Cold soldering is a relatively new phase of this investigation. A proposal has been made that further work be initiated to extend the useful range of this technique. • • •

WORTH FILING

Uni-Tunnel Diode — Silent Film Version

"Tale of the Hoffman Uni-Tunnel Diode — or, How Low Can You Get?" is a humorous treatment of questions (illustrations taken from silent films) but with the serious technical answers on how to use the Uni-Tunnel diodes. It details the electrical and physical parameters of the Hoffman Uni-Tunnel Diode, testing criteria, and presents typical applications.

Source: Hoffman Electronics Corp.
Los Angeles, Calif.
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Pulse Generators

Twelve page booklet describes the uses and applications of pulse generators with particular emphasis on high-speed transistorized circuits. Features, advantages and limitations of a new all solid-state pulse generator designed for use with transistorized circuitry are fully explained. The effect of output impedance on pulse shape distortion is said to illustrate the benefits of an output impedance claimed to be 1/5th that of competitive generators.

Source: Valor Instruments, Inc.
Gardena, Calif.
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3 new additions to the SPRAGUE MADT* transistor line!

TYPE 2N768

- Micro-energy switch—designed for low current, low voltage, high speed applications
- 10 mc pulse rates, collector currents as low as 1 ma, collector supply voltages as low as 1 volt
- No reduction in switching speed, as with ordinary low current, low voltage devices. Permits higher density packaging
- Typical DC beta of 40 @ $V_{CE} = -0.20$ v, $I_C = -2$ ma

TYPE 2N769

- World's fastest switch—will operate reliably at speeds in excess of 100 mc
- Gain bandwidth product (f_T) typically 900 mc
- Low capacitance, low saturation voltage, high beta—ideal for low-level, high-frequency logic circuits
- Extremely low hole storage factor (K'_s) typically 18 nsec

TYPE 2N779

- Manufactured with tighter parameter control than any other transistor in the industry
- Designed to meet rigid specifications of 16 electrical characteristics—ideal for NOR logic and other supercritical applications
- Low saturation voltage—typically 0.12 volts
- Higher in performance, lower in price than mesa transistors with lesser specifications

High-speed switching transistors in TO-18 cases are now being mass-produced by Sprague. These hermetically-sealed germanium Micro-Alloy Diffused-base Transistors are made by a controlled-etch process to insure extreme uniformity. Maximum frequency capabilities have been improved by graded-base construction. Automated manufacturing techniques have brought about increased production efficiency, permitting favorable reductions in prices. This is why Sprague MADT Transistors can offer you greater performance per dollar than other high-speed devices in low-current switching circuits.

Other Sprague Micro-Alloy Diffused-Base Transistors

TYPE	APPLICATION
2N499	Amplifier, to 100 mc
2N501	Ultra High Speed Switch (Storage Temperature, 85 C)
2N501A	Ultra High Speed Switch (Storage Temperature, 100 C)
2N504	High Gain IF Amplifier
2N588	Oscillator, Amplifier, to 50 mc

For complete engineering information on the types in which you are interested, write Technical Literature Section, Sprague Electric Company, 459 Marshall Street, North Adams, Massachusetts.

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CAPACITORS	PULSE TRANSFORMERS	CERAMIC-BASE PRINTED NETWORKS
RESISTORS	PIEZOELECTRIC CERAMICS	PACKAGED COMPONENT ASSEMBLIES
MAGNETIC COMPONENTS	PULSE-FORMING NETWORKS	FUNCTIONAL DIGITAL CIRCUITS

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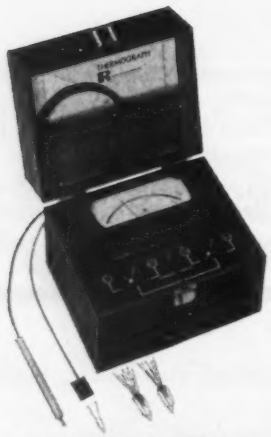

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THERMAL TEST SET

A compact, portable unit for obtaining temperature measurements in electronic equipment — from the individual component to the package itself. Applications include: transistors, diodes, tubes, transformers, micro-miniature circuits, etc.

Direct readings . . . no calibrations . . . rugged construction.

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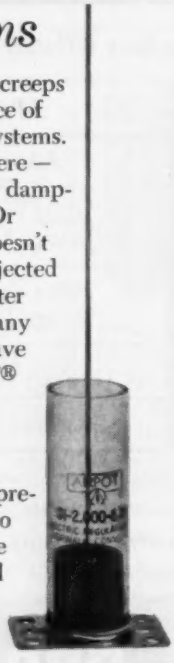
When the
UNPREDICTABLE
happens

• • • the kind that creeps into the performance of newly completed systems. (Excess vibration here — slight time delay or damping needed there. Or perhaps stability doesn't match the data projected on paper.) To counter these variations, many of our customers have found the AIRPOT® an inexpensive problem solver.



AIRPOT is an air-damping dashpot; precisely constructed to operate within close tolerances. Its small size will rarely disturb a system's basic design.

To learn more about the AIRPOT, contact us at:

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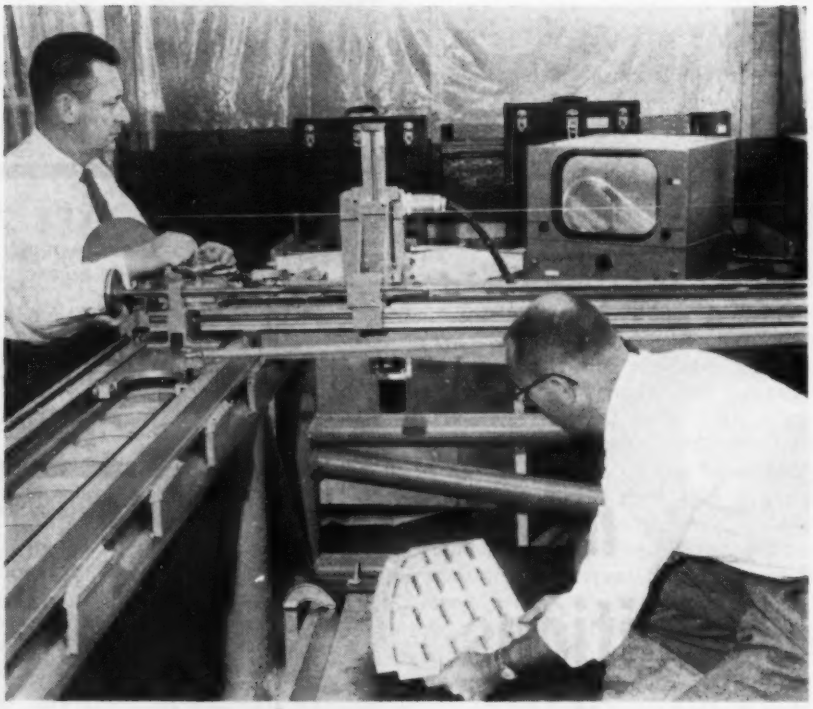


PRECISION INSPECTION

40-70 per cent Time Reduction With Closed-Circuit TV System

Use of a closed circuit industrial television system significantly advances inspection techniques of large mechanical sections. Convair, division of General Dynamics Corp., San Diego, Calif., developed the inspection method to greatly reduce the time required for making a complete dimensional check of aircraft parts.

Under the older method, large machined sections that were to be checked for dimensional accuracy were fixed to a surface plate and measured with a height gauge. To make a second measurement along another axis required a complete new set-up of the piece, a procedure sometimes involving hours.

To lick this time problem, Convair engineers designed a "universal inspection machine" built around a closed circuit television system manufactured by the Kin Tel Division of Cohu Electronics Co. The inspection machine has a frame of welded pipe, rectangular in shape, measuring about 6x8x3.5 feet high. The interior is open so that large sections can be placed inside on a two foot-high table. Across the top of the rectangular frame is a carriage that can be moved from one end of the frame to the other. This carriage holds the television camera on a bracket that can also be moved back and forth by a rack and pinion arrangement. The camera can then be moved to any position over the inspection table.

Distance traveled, in either direction, is easily determined by the two vernier scales, both accurate to 0.001 in. The camera lens, focused by remote control, is a telephoto type, enlarging the field of view about 30X; a cross hair on the lens aids in precise positioning. A Kin Tel 14 inch television monitor is placed near the inspection machine to show the operator the position of the camera over part to be inspected.

To make a measurement, the operator locates the cross hair on one edge of the test section by sighting it with the TV monitor, records the vernier reading and then moves the carriage assembly to the other side of the part for a second reading. The subtraction of the two figures is the true dimension. Because the camera can move in both axes, the procedure can be repeated in the other direction, thus obtaining a complete dimensional check without altering the position of the test part.

Reduction in set-up and inspection time using the system has been significant. Convair engineers estimate, comparing the older method to the television inspection method, time savings ranging from 40 to 70 per cent.

Write No. 169 in Box on Inquiry Card

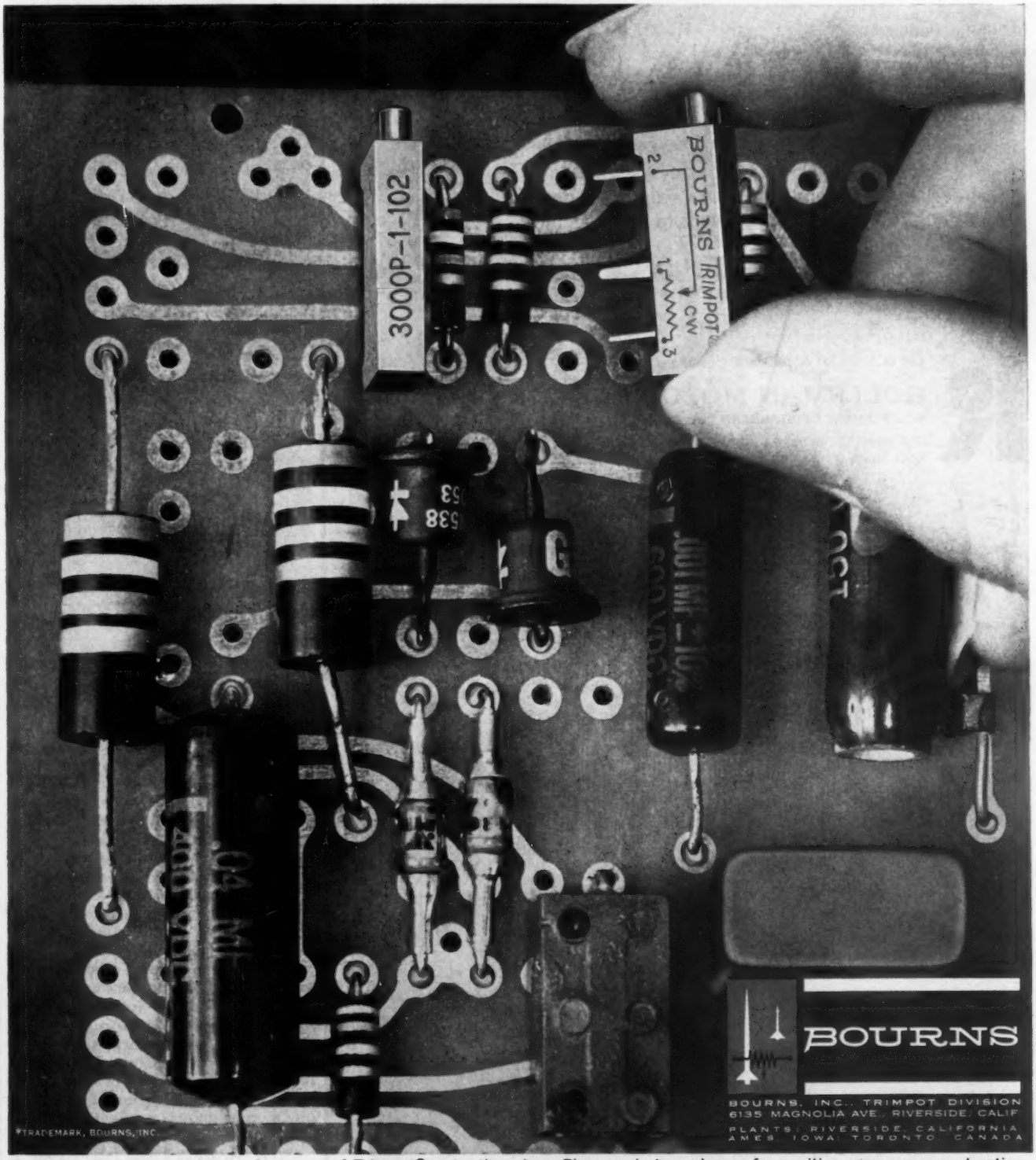
NUMBER 13—NEW PRODUCT SERIES

Now—an Even Smaller High-Temperature Trimpot® Potentiometer

Here, just ¾" in length, is a wirewound potentiometer that is completely humidity-proof and operates at 175°C! Ideal for your printed circuit applications, it withstands 30G vibration and 100G shock, dissipates 0.5 watt at 70°C (0.2 watt at 125°C), and has tapered pins for quick, easy mounting.

Sealed against humidity in a high-temperature plastic case, the Model 3000 exceeds the requirements of MIL-STD-202A, Method 106. The 15-turn screwdriver adjustment permits pinpoint settings and the self-locking shaft keeps them accurate. For maximum stability, the unit incorporates a ceramic mandrel. Reliability is outstanding. The exclusive Silverweld® bond between terminal and resistance wire is virtually indestructible under thermal or mechanical stress.

Available within 24 hours from factory and distributor stocks, the Model 3000 is stocked in resistances of 50 ohms to 20K. A Resiston* carbon version, Model 3001, is available with resistances of 20K to 1 Meg. Write for complete data and list of stocking distributors.



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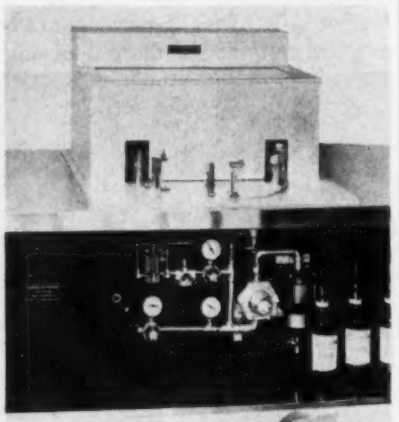

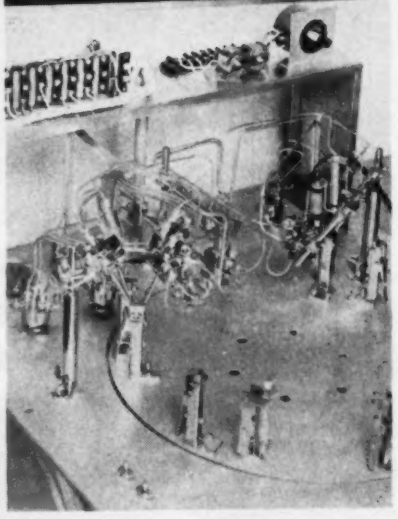

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WORTH FILING

Rectifiers

To assist in selecting optimum silicon and germanium rectifier components for basic circuits, two wall charts enable circuit designers to choose the right device without time consuming reference to specs and other information sources. A "Rectifier Selection Chart" indicates optimum devices based on the following parameters: average amps per cell, recurrent peak reverse voltage (PRV) and temperature. If PRV and average amps per cell are not known, this data can be obtained from other wall chart "Characteristics of Common Rectifier Circuits."

Source: General Electric Co.
Auburn, N. Y.

For Your Copy: Write No. 805 on Inquiry Card

Power Transistors

Two hundred page handbook is devoted entirely to power transistor theory, design and applications. Supplemented by more than two hundred drawings and charts, plus numerous design problems and solutions, the handbook serves as a reference as well as an introduction to power transistor applications. Mechanical, electrical, and thermal characteristics, plus maximum ratings and characteristics are comprehensively covered. Other valuable information includes circuit designs, selection charts, representative specifications, derating curves and comprehensive list of symbols and abbreviations. Price: $2.00.

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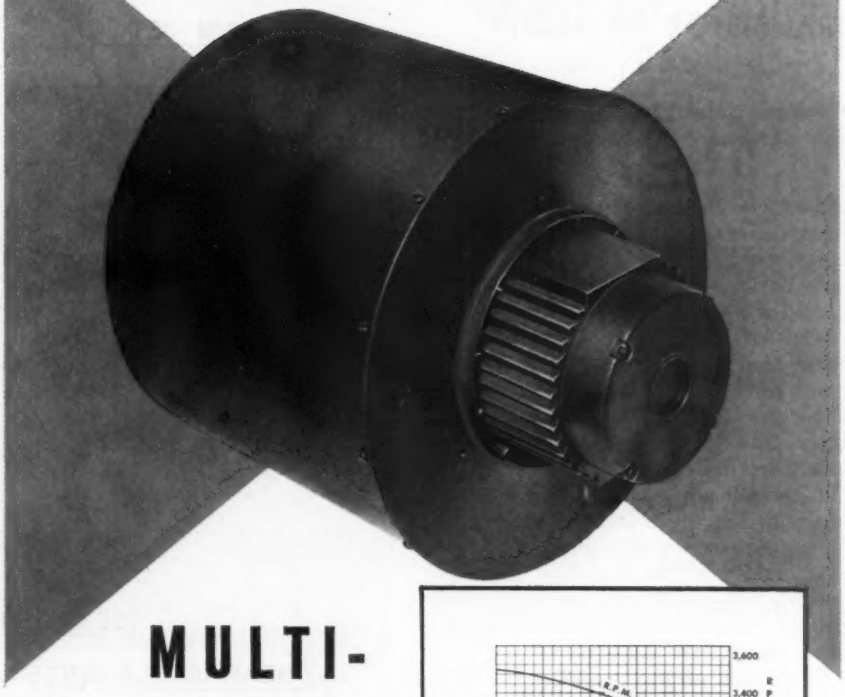
the pressure's on for '61



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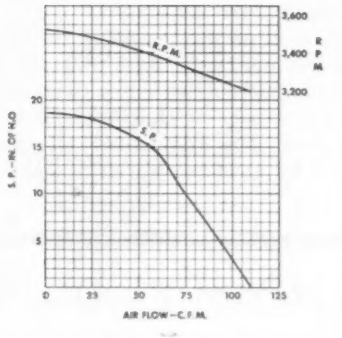

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TRANSISTOR RELIABILITY

"Helium Bomb Test" Improves the Detection of Leakage

Manufacturing and testing innovations have increased the reliability of transistors produced at Philco Corp. (Lansdale Division) and at Delco Radio Division of General Motors Corp.

Delco's latest contribution to transistor technology consists of a "helium bomb test" for checking transistor leaks. Transistors are immersed at high pressures into a helium filled container where helium penetrates any transistor not hermetically sealed. After a washing with air, the transistors are placed in an evacuation chamber. The gas, evacuated from the chamber, then undergoes standard tests for detecting helium. The system monitors leak rates down to 10^{-10} cu. cm/sec.

Helium in no way damages the transistors and permits a 100% test without the use of radioactive gases or damaging water vapor. At Delco, the "helium bomb test" has supplanted all other methods for checking transistor leaks.

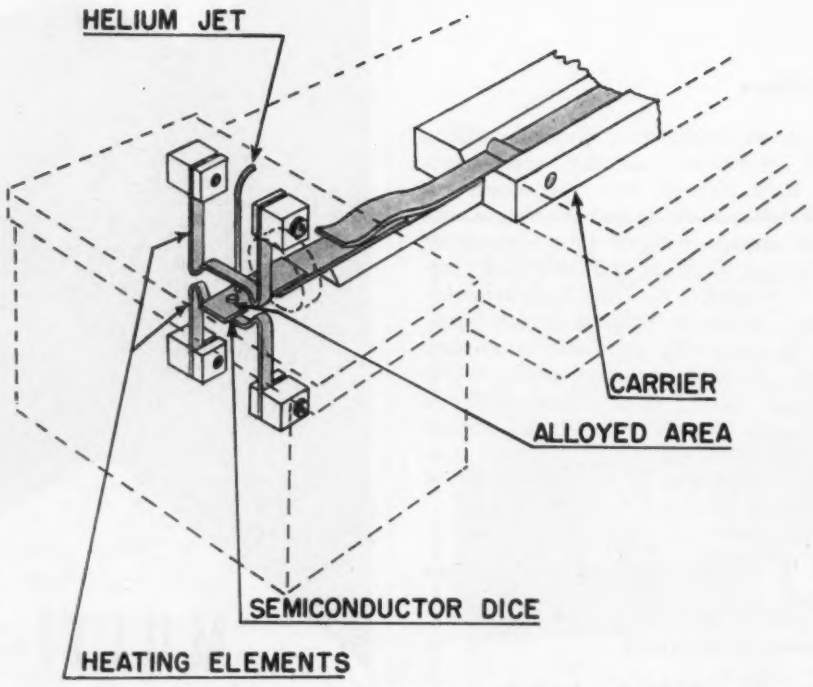

Fig 1 A new fabrication technique, "strip alloying," is used by Philco Lansdale Division to produce SPAT transistors. Each transistor dice is indexed on a precision carrier which guides it into a minified alloying furnace and perfectly aligns it with the heat source. In this manner, every transistor is alloyed identically, leading to high beta, very low saturation voltage and high emitter base diode voltage characteristics.

GREATER PRODUCT UNIFORMITY RESULTS FROM NEW PROCESS

Philco Corp's "unique strip alloy technique" has led to the development of the silicon precision alloy transistor (SPAT), an upgraded medium frequency unit. "Strip alloying" permits an accurate measurement of the diode voltage and beta of every SPAT during manufacture. In the process, each SPAT is indexed on a precision carrier which guides the unit into a minified alloying furnace and perfectly aligns it with the heat source. Thus, every transistor receives identical heat treatment.

Specifically designed for switching and control applications, transistors produced by "strip alloying" feature high beta, very low saturation voltage and high emitter base diode voltage ratings.

For more information on Delco's transistors:
Write No. 180 on Inquiry Card
For more information on Philco's transistors:
Write No. 181 on Inquiry Card

Position-Indicating Systems

Guide to selecting position-indicating systems incorporated into 24-page catalog describes entire line of position instruments for aviation industry. Also covered is dc selsyn test kit capable of testing indicators and transmitters on aircraft or at overhaul facilities.

Source: General Electric Co.
Schenectady, N. Y.
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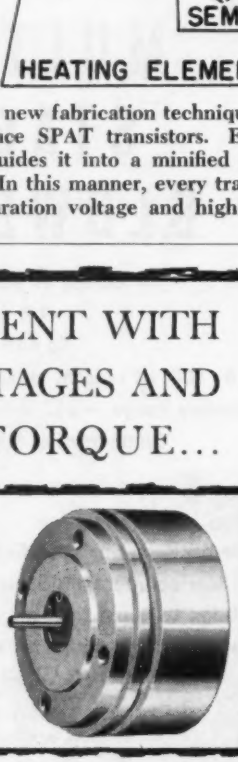

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CIRCLE NO. 30 ON INQUIRY CARD

PARTS DESIGN AND PRODUCTION

One Computer Program Provides Both Automatic Drafting And Production Of Machine Parts

Complex engineering drawings can now be produced by electron beams in less than one-half second from information supplied by a computer. A microfilm recorder developed by Stromberg-Carlson, San Diego, Calif., draws lines, curves, symbols and dimensions necessary to make detailed multi-view drawings.

L. H. Orpin, general manager of the company, stated that this automatic drafting concept will reduce design time substantially saving invaluable engineering man-hours and eliminating costly mistakes in automated manufacturing. "In one method now used, for instance, it requires from several days to a month to take a design engineer's ideas, transmit them to a draftsman, then produce an engineering drawing for the machine tool operator who makes the parts," he explained. "Now, a computer can be programmed with the contours and specifications of the part to be designed and the information transferred to the S-C 4020 high-speed microfilm recorder." Once the engineering specifications are placed in the computer, Stromberg-Carlson's S-C 4020 produces drawings of any view or cross-section of the part in three dimensions. Figure 1 describes the complete system that results in greater speed and control of automatic parts production by using the same computer code to produce the parts drawing and the magnetic tapes that operate the machine tools.

The S-C 4020 records information on 35-mm microfilm. Printing is accomplished by photographing displays on the face of a Charactron Shaped Beam Tube, the heart of the microfilm printer. The versatility of the tube permits the drawing of straight lines, arcs, circles, dotted lines, arrow heads, letters of the alphabet, numbers and various other symbols.

Compact size of the 35-mm film provides permanent storage of large quantities of data in minimum space. Any individual frame can be photographically enlarged and reproduced in any quanity. An accessory unit permits automatic processing and projection of the film on a 2′ x 2′ screen within 8 seconds. The recorder can also produce complex wiring diagrams, layout work and other processes requiring calculations.

The original S-C 4020 recorders were designed as readout equipment for computers and as data plotters. Their capabilities include recording data on microfilm at 17,500 points per second, plotting graphs on microfilm at 12,500 points per second, recording complex logic circuit drawings and tabular printing.

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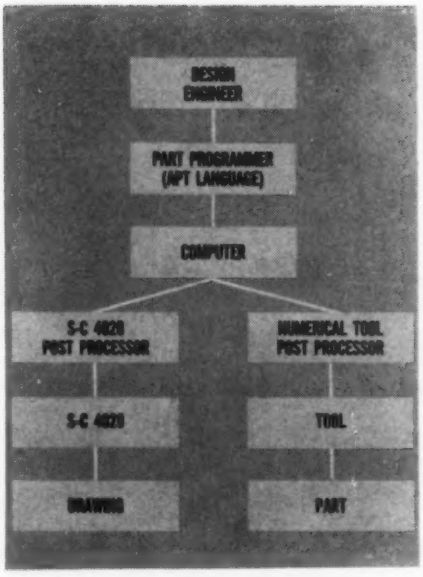

Flow chart illustrates the sequence of steps that can streamline the design and production of parts, saving time and money. The box at the top represents the design engineer who decides what kind of part is needed and lays down the specifications for it. Next, the parts programmer programs a computer with the contours and specifications of the part, using APT (Automatically Programmed Tool) language. APT language is a numercial code developed to control the operation of automatic machine tools of all kinds. Next, the computer stores in its memory all of the engineering specifications of the part, An S-C 4020 post processor produces a magnetic tape of all the specifications of the part. This tape is placed on the tape input unit of the S-C 4020 Recorder. After the drawing has been completed by the S-C 4020, it can be taken to the design engineer and the parts programmer to ascertain whether the part meets all of the requirements. Once the drawing is approved, the same computer code that produced it is used, by means of a numerical tool post processor, to produce a magnetic tape that will operate an automatically programmed tool.

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MATERIALS

CERAMOPLASTICS

Precision-Moldable Insulation Material Withstands up to 1200F.

Development of Supramica 620 "BB", a ceramoplastic, ultra-high temperature dielectric, by Mycalex Corp. of America, Clifton, N. J., widens the range of problems ceramoplastics can solve in the vital area of missile and space research. Heat generated by even the most modern high-speed and miniaturized electronic equipment will have no effect on Supramica 620 "BB" parts. The new ceramoplastic can be molded to the most complex geometries with gauge-like tolerances.

Fig 1 Six terminal hermetically sealed heads precision molded from Supramica 620 "BB" ceramoplastic.

Hermetic sealing capabilities of a properly designed Supramica 620 "BB" part clearly surpass generally accepted standards. A group of precision-molded component parts were subjected to a helium mass spectrometer leak detector sensitive enough to detect leaks as small as $2X10^{-10}$ cc/sec helium per second. They tested at the optimum — no signs of leakage. The generally accepted standard, which the detector would have easily spotted, is $1X10^{-8}$ cc/sec helium, equivalent to the loss of about 3 cc's of helium in 10 years.

Supramica 620 "BB" retains its insulation resistance at elevated temperatures; at 932 degrees F., its volume resistivity is $1X10^{8}$ ohm — cm. The thermal expansion factor of the new material matches that of many metals, thus it can be precision-molded with metal inserts including titanium for the most perfect possible seals even under widely and quickly varying temperatures.

Supramica 620 "BB" shows excellent loss characteristics. During ASTM test procedures, it exhibited an 0.020 loss factor at 1 megacycle. It is completely impervious to oil, water, humidity and organic solvents and will not carbonize. The ceramoplastic's arc resistance has been established at 300 seconds by ASTM test procedures and its dielectric strength, again using an ASTM test, has been proven at 270 volts/mil. Supramica 620 "BB" exhibits total dimensional stability, even under the most adverse thermal cycling and parts made from the material have an indefinite shelf life.

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Curing Epoxy Resins

In curing epoxy resins, liquid alkendic anhydride provides long pot lives, ease of mixing, lower density and very low vapor pressures during cure, thereby reducing material losses. Cured products have high heat distortion temperatures, low shrinkage and good ageing characteristics at elevated temperatures. Alkendic anhydride also used in alkyd resins, plasticizers, and rust-inhibiting compounds, has low viscosity and good compatibility with other chemicals; it resists hydrolysis caused by atmospheric moisture. Amchem Products, Inc., Ambler, Pa.

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Permanent Magnet Material

Rubber bonded barium ferrite, a new permanent magnet material, may be easily machined or cut by ordinary tools. Its magnetic properties compare to that of sintered isotropic barium ferrite, but unlike the latter, the new material is neither hard nor brittle. It has high coercive force, high impact strength and an energy force of about one million gauss oersteds. Leyman Corp., Cincinnati, Ohio.

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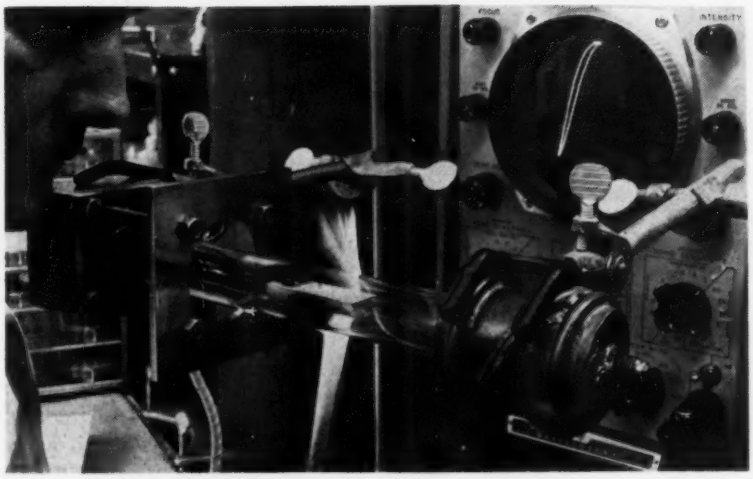

The silicon carbide transistor undergoes high-temperature testing at the Westinghouse materials labs. The transistor is the tiny speck inside the clear quartz tube being heated by the gas flame. Although heated to temperatures at which conventional germanium or silicon transistors fail to operate, the trace on the oscilloscope shows that the silicon carbide transistor functions perfectly.

HIGH-TEMPERATURE TRANSISTOR

Operation at 925F Predicted For Silicon Carbide Unit

Although still in the laboratory stages of development, the high-temperature capabilities of a new transistor make it a significant advancement in the technology of semiconductor devices. Capable of operating above 650F, the transistor is made from silicon carbide, a hard crystalline material which, in impure form, is used as an abrasive in grinding wheels. The transistor was developed at Westinghouse Electric semiconductor department, Youngwood, Pa., under sponsorship of the Electronics Research Directorate of the Air Force Cambridge Research Laboratories.

Present-day transistors manufactured almost exclusively from germanium and silicon, can operate at temperatures no higher than about 200F (germanium) to 400F (silicon). Laboratory tests show that the silicon carbide transistor amplifies and has power gains greater than unity up to 670F, and with further development, Westinghouse scientists foresee its upper operating temperature at more than 925F.

The new unit is a unipolar transistor which differs in operating principle from the bipolar type usually made from germanium and silicon. The bipolar transistors regulate the flow of an electric current through them by the injection of electric charge carriers across a junction built into the semiconductor material. On the other hand, the unipolar transistor acts more like a valve which opens or closes to regulate the electron flow across the junction.

Westinghouse scientists report that two advances have made possible the unipolar silicon carbide transistor; the availability of silicon carbide crystals of exceptional purity which were produced by Dr. D. R. Hamilton of the Westinghouse research laboratories; and the perfection of techniques to form the semiconductor junction in the material – to clean, etch, solder, and otherwise handle the inert silicon carbide crystals. These crystals, about two-thousandths of an inch thick, have less than one part impurity in 10 million parts of silicon carbide.

The semiconductor junction is built into the material by exposing it to vaporized aluminum at the white-hot temperature of 3900F. The aluminum atoms diffuse into the silicon carbide crystal, changing its electrical behavior from n-type material to p-type. The junction is formed where the two types meet, and the diffusion process is controlled to within a few millionths of an inch.

To construct the input and output terminals of the transistor, the wafer is etched at two points until the junction within the body of the crystal is reached. Electrical connections at these two points and to the body of the wafer complete the transistor.

A typical finished transistor is about 80-thousandths of an inch long and 40-thousandths of an inch wide, and the "working" area of the crystal surface is smaller than the head of a pin. Finished transistors have a power gain of about 60 at room temperatures. •••

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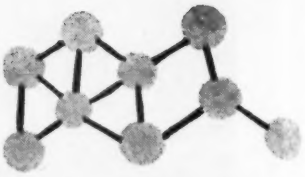
by **David Bandel** *Staff Columnist*
Associate Technical Director,
TRACERLAB, INC.



MATERIALS

Cadmium oxide is used in place of the usual tin compounds in a new transparent, electrically conducting film. The cadmium oxide film can be layed down from solution by conventional coating techniques. The part, in most cases glass, is dipped in a cadmium compound soluble in organic solvents. Nitrocellulose is used as a temporary binder and film former. After evaporation of the solvent the part is heated to volatilize the nitrocellulose and convert the cadmium compound to the oxide, leaving a transparent conductive film.

Improved magnetic alloys have been developed by Hamilton Watch Co. Designated Vapalloys, these materials have been used in the Univac 1107 thin film computer. Use of thin films of Vapalloys is said to be responsible for the fast memory access time of the computer, 10^{-7} sec. Vapalloys are produced by induction melting high purity iron, nickel and cobalt under careful control. Since subsequent application of Vapalloys is in ultra-high vacuum systems, residual gas content is maintained as low as possible; less than 1 part per million hydrogen and nitrogen. Oxygen content is slightly higher since solid de-oxidizers are avoided.

Composite metal seals that will withstand pressure cycling from 0 to 5,000 psi at temperatures up to 1500°F are under development at Armour Research Foundation. Materials having high temperature resistance generally lack conformability while high conformability materials lack temperature resistance. A unique method of blending of the two types of material produces seals that possess the best features of each type. The Armour composite seal is made of a hard matrix impregnated with a softer metal. The hard metal matrix imparts high temperature strength while the soft metal provides the sealing action. The matrix is prepared by melting metal fibers and then sintering the fibers to form a porous mass. The most successful matrix materials thus far have been molybdenum and stainless steel. Silver is the choice for the soft material. No. 430 stainless steel and a silver-indium alloy performs almost as successfully. One problem that has to be overcome is lack of resilience of these seals. So far, it has not been possible to eliminate compression set. Ceramic-silicone rubber combinations have also been tested to 1200°F and 5,000 psi but the silicone stuck to the flanges and required refacing of the flanges after the seal was dismantled.

An interesting new organic fabric with extreme temperature resistance has been developed by Minnesota Mining and Manufacturing Co. The heat resistance of the fabric, called Pluton, is graphically demonstrated by pouring molten steel at 3000°F into a square of the fabric and permitting the steel to solidify. The steel slug is then removed without any signs of charring or melting of the fabric. Actual heat resistance temperature claimed for Pluton is 18,000°F. Phenolic Pluton laminates will resist 5,000°F. The low thermal conductivity of Pluton, 0.42 BTu/hr/sq. ft/°F, makes it particularly useful for high temperature reinforced plastic laminates.

Continuing R & D on graphite cloth – a high-temperature material being extensively evaluated for missile components – has resulted in significant advances. Combined with phenolic resins to produce a high-pressure molding compound, graphite cloth has been tested in exit systems in the development of solid fuel rocket engines. Modification of the complex processing techniques employed in converting organic fibers to essentially pure graphite has increased the previous 8-pound average breaking strength of graphite cloth to 25 pounds, and at the same time has doubled the flexibility. The properties cited are for one-inch wide strips of cloth tested according to ASTM specification D 39-59. This increase in strength is expected to point the way to still more military and industrial applications for graphite textiles.

Panel Enclosures

NEMA Type 4 (watertight) panel enclosures made of sheet steel are designed to house electrical controls in areas which must be regularly hosed down or are otherwise very wet. Because they are made of sheet steel, holes for watertight conduit connections are easily made anywhere on the cabinets. Furthermore, modifications and special sizes are readily available using the basic design. Cabinet doors have one-piece, solid neoprene gaskets and are sealed tightly by screw clamps on three sides. The fourth side of the door has a continuous hinge. All cabinet seams are welded to prevent leakage. Each enclosure has a removable panel mounted on studs. A removable print pocket is located on the door. Exterior mounting feet are provided for wall-mounting the cabinet. Hoffman Engineering Corp., Anoka, Minn.

Write No. 588 in Box on Inquiry Card

Silicone Rubber

Heavy metal particles are very finely divided and uniformly dispersed in silicone rubber. From a series of initial tests conducted thus far, results show the properties of the metal-filled silicone rubber to be: broad temperature range of −85 to 500 F; good resistance to weather, ozone and ultraviolet light; unusually uniform shielding against X-rays or other high energy radiation; good electrical resistance properties (10^{17} ohm-cm); high specific gravity; a resilient and flexible material. Conn. Hard Rubber Co., New Haven, Conn.

Write No. 614 in Box on Inquiry Card

Epoxy Plus Coal Tar

Epocast H-1338 combines epoxy resins and coal tar derivatives to form a low-cost dielectric which has opened new areas for electrical encapsulation. The new system for impregnating and encapsulating has been used in industrial applications of Clas A insulation of transformers, terminal boards and miscellaneous electrical components. Furane Plastics Inc., Los Angeles, Calif.

Write No. 615 in Box on Inquiry Card

Preformed Insulations

Physical properties and insulating values of Refrasil-vitreous silica fiber cloth remain in tact at temperatures of 1800°F, in radiation environments. The new material is for use in the field of preformed electrical insulation components. Stevens Products Inc., East Orange, N.J.

Write No. 609 in Box on Inquiry Card

Vinyl Compound

New vinyl compound meets needs for 90°C wire and government specs for 1/32" and 1/64" wall thickness. It passes UL requirements after 7 days aging at elevated temperatures where a complete margin of safety is required. It also meets CSA requirements of 14 days at 121°C with a very high margin of safety. The compound has outstanding high and low temperature characteristics that makes it a versatile material for many applications. The Blane Corp., Canton, Mass.

Write No. 608 in Box on Inquiry Card

Plastic Laminates

A color-fast, uniformly dense black, glass-reinforced epoxy laminate is said to offer properties ideally suited to adverse temperature and humidity operating conditions. It has high insulation resistance, very low water absorption and high stability in humidity. Without blistering or bond failure, a copper-clad grade makes printed circuits in 30 minutes when boiled in trichloroethylene, over 30 minutes in gold-cyanide solution, or 2 minutes in a 500F solder bath. General Electric Co., Coshocton, Ohio.

Write No. 601 in Box on Inquiry Card

Immersion Rhodium Plating

Expected to find wide application in electronics, an immersion (electroless) rhodium plating bath offers "unlimited possibilities" in making printed and etched circuits; no electrical contact is needed in plating to deposit an easily solderable, corrosion-resistant finish. The immersion rhodium, a moderate-priced stable solution, deposits a tight-grained, pore-free deposit of rhodium on copper or nickel. Manufacturer reports a 5-minute deposit over copper will withstand a 30-minute immersion in a 50% nitric acid solution. Technic, Inc., Providence, R. I.

Write No. 602 in Box on Inquiry Card

Non-Oriented Alnico

For use in magnetic core-type meters and instruments, Alnico VII-S, a permanent magnet material has a non-oriented energy product of 2.5 million. Non-oriented core magnets provide a more uniform gap density which enables a more linear and accurate scale in the meter than was formerly possible with oriented materials. Alnico VII-S resists demagnetization even when subjected to high environmental heat. Indiana Steel Products, Valparaiso, Ind.

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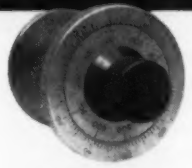
One Step Purchasing **One Step Installation**



TIC

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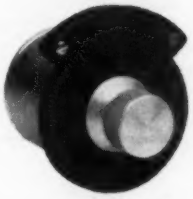

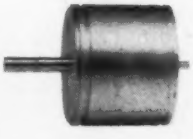

• TIC Drives save time, trouble and money — eliminate the need of procuring and assembling separate indicators, dials, knobs, gears, etc. And, with TIC Precision Drives you know you have a unit that will do the required job without a possibility of error. Use them with rotary components such as resolvers, synchros, potentiometers, inductors, capacitors, tuning coils, etc.

• TIC packaged Precision Dual Speed Drives are manually operated or motor driven, precision gear reducers to produce accurate shaft positioning with excellent readability. If your synchro, resolver, potentiometer or other rotary devices require precise positioning and readout, TIC Drives provide a complete package, including couplings and mounting hardware, to allow accurate and repeatable settings to within 1 minute of arc.

• No backlash. Meet MIL-E-4970 (USAF). Panel or Modular Mounts available. Gear Reductions up to 180 to 1.

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TESTING

PULSED X-RAY SYSTEM

Behavior of Encapsulated Components Under Vibration Can Now Be Observed

Generating short pulses of high intensity X-rays at a high repetition rate, Zenith Radio Corp.'s new pulsed X-ray system produces cineradiographs of high speed phenomena in one microsecond or less. Dr. L. C. Foster, director of research at Zenith's Menlo Park, Calif. facility, expects that the system will have widespread application in the fields of shock and vibration studies, radiation effects, rocketry, medical radiology, ballistics, and crystallography.

During demonstrations of the system, specialists in the field of vibration and shock testing observed, for the first time, the behavior of encapsulated components under vibration conditions. The heater of a vacuum tube, visibly shielded by surrounding components, was readily observed going through violent excursions which could only lead to heater failure. Also observed was the "chatter" of contacts and resonances of other structures in a sealed relay. "It is entirely conceivable," Dr. Foster stated, "that the Zenith system of analysis by X-ray will become a standard test for critical components subjected to extremes of vibration and shock in their normal operating environment."

Heart of the X-ray system is Zenith's oxide-coated thermionic hot cathode X-ray tube that is capable of conducting high currents at high voltage with fast rise time characteristics. With a life in excess of some million shots, the tube was proven, in tests, to have excellent reproducibility of pulse length, voltage, current and, consequently X-ray output characteristics. Prior to development of the Zenith tube, Dr. Foster pointed out, high intensity X-ray tubes were limited to a life of several hundred shots, frequently possessed unreliable pulse characteristics, and could be pulsed only once every several minutes.

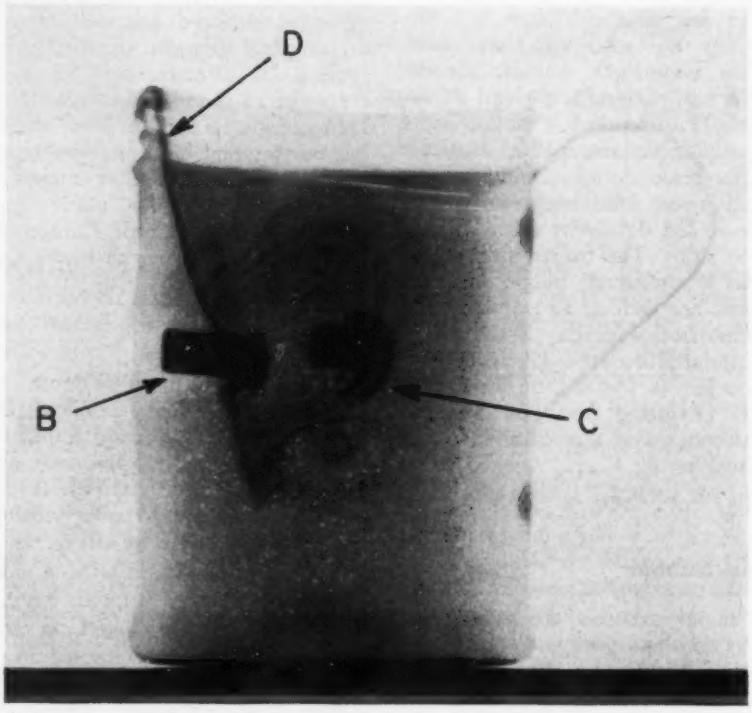


Fig 1. Zenith's new pulsed X-ray system produces X-ray motion pictures of high speed phenomena, such as these two exposures of a bullet in flight taken 1/40,000 of a second apart at speeds of one millionth of a second or less. Shown are two successive X-ray photos of the same bullet traveling 4,000 ft. per second in air taken 25 microseconds apart. (B) Bullet enters aluminum salt shaker filled with water and (C) same bullet is photographed a split second later as nose is flattened and mushrooming begins. Trigger mechanism (D) initiated X-ray series. X-ray tube is pulsed with a square wave voltage pulse one microsecond in duration and the rate of application is continuously variable from one to 30 pulses per second. Amplitude of the square wave voltage applied to the tube is continuously variable from 0 to 150 kv. When the tube is operated at 150 kv with a beam current of 130 amps, the X-rays are generated by an electron beam of approximately 20 megawatts focused on the X-ray conversion target. The resulting high intensity X-rays have an effective spot size of 1 x 2 mm throughout the life of the tube and, at 1" from the target, have an intensity rate of 107 roentgens per second.

Fig 2. Zenith's X-ray system is housed in two moveable console units. At left is the X-ray generating console which includes a 20 megawatt pulse generator. Operation requires only 2500 watts of 110 ac, 60 cps power. Intensifier console, at right, requires 400 watts at 110 volts ac, 60 cps. High powered, short pulses of x-radiation are passed through the subject under study and impinge on the X-ray sensitive screen of a Rauland image intensifier tube which is housed in the image intensifier console. The Rauland tube amplifies the X-ray image, and converts it to visible light which appears as a bright image on the tube's output phosphor. The image is suitable for direct viewing, closed circuit television viewing, or for pick-up by a motion picture camera. Sufficient light intensity is available so that very fine grain film may be used for motion picure recording.

Two compact units make up the system — an X-ray console with the X-ray generating tube, its power supply, and control circuits, and the image intensifier console.

The system may be fired manually, continuously by an internal variable rate pulse generator, or may be slaved by any desirable external source so that stroboscopic slow motion effects may be readily obtained. In addition, a reference pulse is available from the X-ray console which may be used to synchronize auxiliary equipment with the X-ray pulse.

An additional feature of the equipment is that a single, one microsecond X-ray pulse has sufficient energy to permit a radiograph to be taken directly on conventional film. Adequate film density is obtained from the single pulse through 1.5″ of aluminum at a distance of six feet from the X-ray tube.

Citing other potential applications, Dr. Foster said that studies can be made of ultra high speed machining, where observation by conventional photographic methods is impossible because of the obscuring effects of smoke and vapor. Alloys and new metal systems can also be checked for reliability under dynamic conditions with regard to resistance to stress, corrosion, etc. Using an X-ray pulse from the Zenith equipment, diffraction patterns of crystals may be seen. Since the pulse length of the x-radiation is so short, the experimenter will be able to analyze the molecular and crystalline structure of crystals under dynamic conditions, and to record transient crystal formations and transformations formerly unknown in solid state physics.

Write No. 179 in Box on Inquiry Card

Wire Tester

Specially designed chamber, measuring 24″ wide, 26″ deep and 72″ high, tests wire and cable at temperatures from +80 to −100°F ±2°F. Pulldown is accomplished in 60 min. Pillow-block construction accommodates test loads of ½ ton. Incorporating a ducted fin coil evaporator on rear wall, the chamber allows unencumbered use of the entire test area. Cincinnati Sub Zero Products, Cincinnati, Ohio.

Write No. 751 in Box on Inquiry Card

Synchro Standards

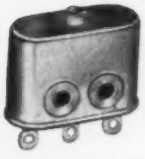
While developing output impedances on the order of milli-ohms, synchro standards achieve accuracies to 2 sec of arc or 10 ppm. Their maximum distortion (quadrature plus harmonics) is 0.005% for rated frequencies. Instruments do not require nulling against a bridge nor careful mechanical positioning. Astrosystems, Inc., N. Y., N. Y.

Write No. 749 in Box on Inquiry Card

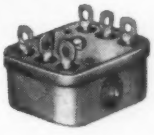
Reliability
IN OPERATING ENVIRONMENT WITH
HAYDON Switch INCORPORATED
SEALED SWITCHES

High temperature
Cryogenics
Corrosive media
Salt spray
Humidity
Oils
Gases
Oxygen
Icing
High Altitude
Explosion
Immersion
Dry circuit
Sand & Dust
Fungus

Standard Hermetically Sealed Switches, SPDT & DPDT


Series 6107

Series 61392


Series 8102

Series 61393 Hi Temp

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Series 7102

1-4 pole Pushbutton and Toggle Sealed Assemblies

Series 61512

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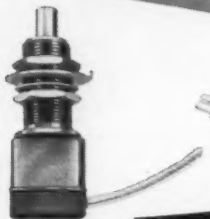
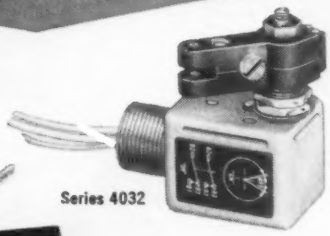
Series 6178

Sealed Plunger and Rotary limit Switches for Landing Gear and similar uses


Series 61358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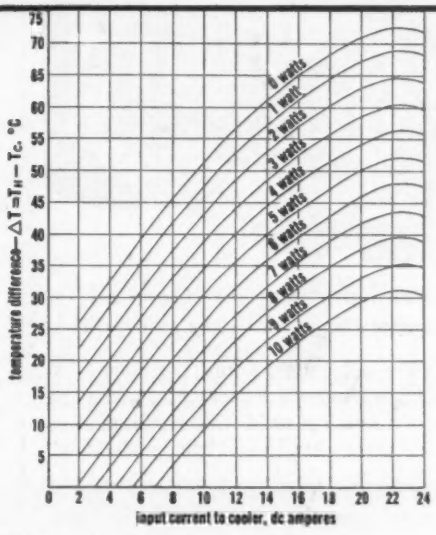
Now you can have the space and weight savings of Westinghouse "Component-Matched" thermoelectric coolers—with new cost savings, too. Prices are reduced on standard units, up to 50%!

Exclusive Westinghouse "Component-Matched" configurations! With no moving parts, Westinghouse Thermoelectric coolers provide dependable, compact, lightweight cooling where it is necessary to reduce component temperature below ambient. These unique "Component-Matched" coolers feature exterior cooling surfaces or inner-cooled chambers with tailor-made dimensions to fit specific requirements. As a result of new production facilities, a wide range of configurations can be offered to electronic equipment designers.

Only Westinghouse guarantees minimum ΔT ratings! Recent Westinghouse improvements in thermoelectric materials and assembly techniques have made it possible to guarantee minimum ΔT ratings for each cooling unit. Thus, a designer can select the unit he needs knowing in advance what the temperature drop will be from the hot to the cold side of the cooler.

Immediate military and industrial applications include: Photocells, photomultiplier tubes / Germanium transistors / Infrared detectors / Mechanical and electrical instruments / Laboratory and portable medical equipment / Controlling temperatures of solids, liquids and gases.

Westinghouse engineers who developed these new thermoelectric coolers will be glad to provide engineering assistance in your applications. For full information, contact your local Westinghouse representative, or write: Westinghouse Electric Corporation, Semiconductor Dept., Youngwood, Pennsylvania. SC-1000



Typical ΔT°C versus input current—Types WX814-H, WX816-H

"Buy and Try"—from Westinghouse distributors—standard WX814 and WX816 Coolers for immediate delivery at new reduced prices.

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CAMERADIO	Pittsburgh, Pa./EX 1-4000
CRAMER ELECTRONICS, INC.	Boston, Mass./CO 7-4700
ELECTRONIC WHOLESALERS INC.	Melbourne, Florida/PA 3-1441
GENERAL RADIO SUPPLY CO., INC.	Camden, N. J./WO 4-8560
GENESEE RADIO PARTS CO.	Buffalo, N. Y./DE-9661
KANN-ELLERT ELECTRONICS, INC.	Baltimore, Md./TU 9-4242
MILGRAY ELECTRONICS	New York, N. Y./RE 2-4400
RADIO & ELECTRONIC PARTS CORP.	Cleveland, Ohio/UT 1-6060
SCHWEBER ELECTRONICS	Long Island, N. Y./PI 6-6520
	Silver Spring, Md./JU 5-7023

MIDWESTERN

ELECTRONIC COMPONENTS FOR INDUSTRY CO.	St. Louis, Mo./WO 2-9917
HALLMARK INSTRUMENTS CORP.	Dallas, Texas/RI 7-9385
INTER-STATE RADIO & SUPPLY CO.	Denver 4, Colo./TA 5-8257
LENERT CO.	Houston, Texas/CA 4-2663
RADIO DISTRIBUTING CO.	Indianapolis, Ind./ME 7-5571
SEMICONDUCTOR SPECIALISTS, INC.	Chicago, Ill./NA 2-8860
S. STERLING CO.	Detroit, Mich./BR 3-2900
UNITED RADIO, INC.	Cincinnati, Ohio/MA 1-6530

WESTERN

ELMAR ELECTRONICS	Oakland, Calif./TE 4-3311
HAMILTON ELECTRO SALES	Los Angeles, Calif./BR 2-9154
NEWARK ELECTRONICS CO.	Inglewood, Calif./OR 4-8440

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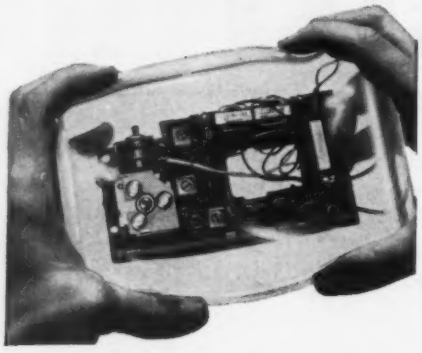
GENERAL ELECTRIC

CLEAR LTV SILICONE COMPOUND

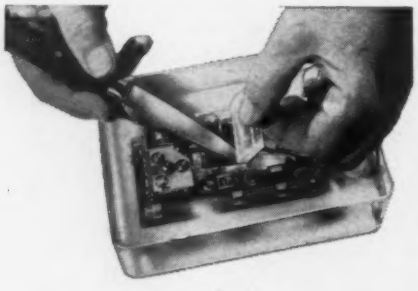
FOR POTTING AND EMBEDDING



Transparent, resilient, self-supporting, and easy to repair.

A clear, solventless liquid, G-E clear LTV silicone compound cures at 75-80°C to form a resilient solid with excellent electrical properties. Useful from —65-175°C.

LTV is easy to apply, flows freely around complicated parts. Unlike "gel-like" potting materials, it cures to a flexible solid. Oven cure is overnight. Pot life is 8 hours.



LTV-602 is easy to work with. To remove embedded parts, merely cut out section, remove or repair part, pour fresh LTV in section, and cure.

Excellent shock resistance, and protection against environmental hazards. LTV retains protective properties even after 1800 hours aging at 175°. Resists moisture and water immersion.

For full details on General Electric silicone potting and encapsulating materials, including new clear LTV and the widely used RTV liquid silicone rubber compounds, write: General Electric Company, Silicone Products Dept., Section NN442, Waterford, New York.

GENERAL ELECTRIC

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TESTING

Three-Phase Generator

Said to be ideal for missile system checkouts, a wide-band electronic generator combines high degree of amplitude and frequency stability with extensive frequency range. The 3-phase generator has an output of 30 va over a frequency range of 50 to 6000 cps. It consists of power supply and amplifier chassis, each requiring 7" of panel height in a standard 19" rack. The new generator is one in a line of units ranging from 60 to 100,000 watts and from dc to 50,000 cps. Communication Measurements Lab., Inc., Plainfield, N. J.

Write No. 750 in Box on Inquiry Card

Voltage And Phase Tester

Highly accurate measurements of phase shifts and voltage ratios in electronic equipment is possible with a new voltage and phase indicator. The precision voltage and phase comparator can be used for highly accurate measurments on in-phase and quadrature voltage components and for harmonic content and noise in ac signals over the 380 to 420 cps range. Applications include testing and checkout of 3 and 4-terminal networks, transformers, gyros, synchros, transducers and resolvers. In-phase error is less than 0.1 percent of maximum reading per range; quadrature error, less than 1.0 percent of maximum reading per range; quadrature reading accuracy, 0.08 percent of maximum reading per range. The device can be used either as a portable test unit or mounted in a standard equipment rack. A dehumidifying heater quickly eliminates internal moisture, ensuring reading accuracy under high humidity conditions. Autonetics Industrial Products, Long Beach, Calif.

Write No. 727 in Box on Inquiry Card

Semiconductor Life Testing

Self-contained switching module reduces by a factor of 50 the cost of life testing semiconductor diodes and rectifiers. These power supplies incorporate the principles of simulator testing as opposed to brute force testing. Each can switch 20 amperes average dc at up to 1500 piv. Each output circuit includes a forward drop equalizing resistor to balance the forward current of the rectifiers on test; it also permits paralleling up to 10 output circuits per module to test devices rated above one amp. Wallson Associates, Inc., Elizabeth, N. J.

Write No. 746 in Box on Inquiry Card

Magnetic Drum Check-out System

Said to be the first available equipment for recording timing tracks and for general check-out of a magnetic drum system, a testing system provides clock recording, clock smoothing, origin and word track recording and test pattern recording. A clock track may be recorded circumferentially around the drum with a pre-selected number of bits, up to 16883. Closure on this timing track may be made better than 50 millimicroseconds. For clock smoothing, once a timing clock has been recorded, the phase shift at the closure point may be further reduced by taking a difference signal from two points on the track and recording on a second track. This smoothing process may be continued indefinitely to obtain a closure error as small as desired. For test pattern applications, a selectable test pattern of "ones" and "zeros" may be recorded on a track. This function is used primarily for testing record head properties and system resolution. FMA, Inc., El Segundo, Calif.

Write No. 730 in Box on Inquiry Card

Pocket-Size Dynamometer

Torque and power loading of electric motors can be accurately measured on the job with a 2½ lb dynamometer. To install, instrument slips onto shaft and collet tightened by hand. In operation, stroboscopic tachometer views the rotating dynamometer. Transmitted torque appears on dynamometer dial, and vpm on stroboscope dial. Hp is then easily calculated, or read from a chart. Model indicates torque up to 22 in-lb in either direction. Accuracy: within ½%. Micro Pump Corp., Danville, Calif.

Write No. 737 in Box on Inquiry Card

Two-Pen Recorder

Recording more than one function at a time, a new two-pen recorder simultaneously graphs on a single chart information which can be expressed in an electrical current or voltage. Its recording range varies from microamps to thousands of amps and from microvolts to thousands of volts. A few of its uses include: checking electrical circuits, determining quality of arc welds, indicating proper settings for anodizing and aiding in medical diagnosis and research. Recorder comes with a two year guarantee, said to be unique-in-the-industry, a throw-away ink well, non-overlapping channels on the 6" wide chart and a price of about $600. Esterline-Angus Instrument Co., Speedway, Inc.

Write No. 752 in Box on Inquiry Card

Transfer Function Analyzer

Applicable to vibration, acoustic, servo, human response and related fields, an analyzer determines response characteristics of control, structural and servo systems as well as electrical networks; it uses a cross-spectral density computation technique. Occupying the space of two 70" standard relay racks, the unit gives output as Nyquist or Bode plots, operates with driving signals that are random or complex periodic, and obtains exact causal relationships between two signals, even when extraneous noise interferes. Gulton Industries, Inc., Metuchen, N. J.

Write No. 740 in Box on Inquiry Card

Differential Current Meter

Measuring and metering current from two transducers either separately or differentially, a current meter monitors temperature, pressure, strain or light intensity simply by attaching the appropriate transducer. Dynamic range: 10^8; it measures currents as low as 10^{-9} ampere full scale. Frequency response: ½ cps at the lowest range, increasing to 30 Kc at least sensitive range. Pre-amplifiers with gain of 10^3 are available for low level work. Eldorado Electronics, Berkeley, Calif.

Write No. 739 in Box on Inquiry Card

Torque Calibrator

With a measuring range extending from 0.5 to 40.0 oz-in at an accuracy of ±0.2% of indicated reading, a primary standard measures torque and calibrates torque devices. Its three scales are calibrated in both oz-in and gm-cm. Widely separated calibration points on the dail provide easy reading on all six bi-directional ranges. Equipped with three accurately calibrated weights, units use weight-vector principle (no springs.) Certificate of calibration comes with each unit. Waters Mfg., Inc., Wayland, Mass.

Write No. 741 in Box on Inquiry Card

Tuning Fork Oscillator

Assuring high tone standards for telemetering, tuning fork oscillators provide a source of stable frequency standards for 400 cycle portable power supplies. They give a frequency accurate to ±0.002% over a temperature range of 0 to 65°C for any combination of voltage, attitude and age variables. Prime frequency range: 360 to 6000 cps. Units which operate at temperatures between —55 and +125°C are available at reduced accuracy. Other models have frequencies of 50-30,000 cps. Fork Standards, Inc., Chicago, Ill.

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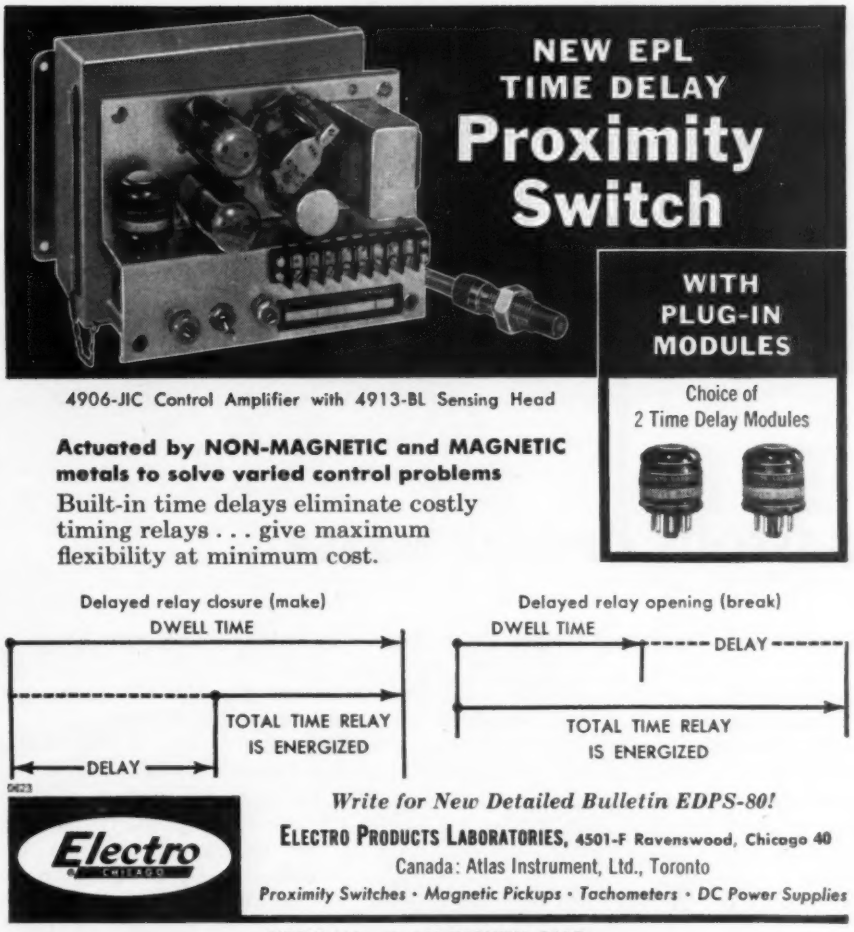
NEW EPL
TIME DELAY
Proximity
Switch
WITH
PLUG-IN
MODULES
Choice of
2 Time Delay Modules
4906-JIC Control Amplifier with 4913-BL Sensing Head
Actuated by NON-MAGNETIC and MAGNETIC metals to solve varied control problems
Built-in time delays eliminate costly timing relays . . . give maximum flexibility at minimum cost.
Delayed relay closure (make)
DWELL TIME
DELAY
TOTAL TIME RELAY IS ENERGIZED
Delayed relay opening (break)
DWELL TIME
DELAY
TOTAL TIME RELAY IS ENERGIZED
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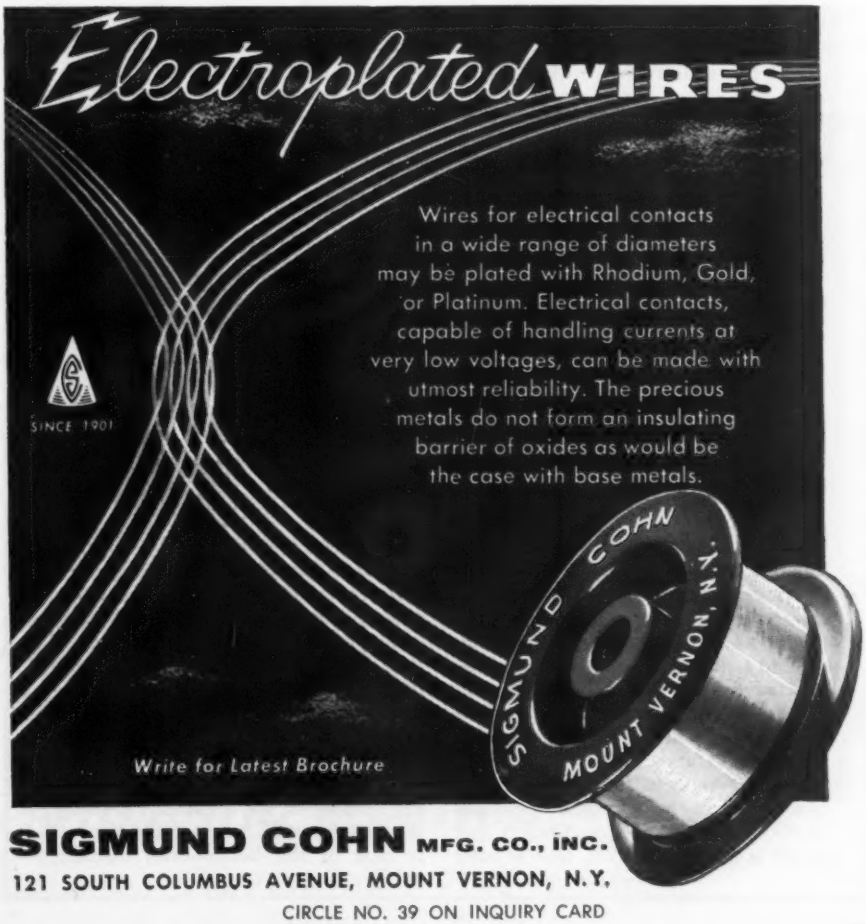
Electroplated WIRES
Wires for electrical contacts in a wide range of diameters may be plated with Rhodium, Gold, or Platinum. Electrical contacts, capable of handling currents at very low voltages, can be made with utmost reliability. The precious metals do not form an insulating barrier of oxides as would be the case with base metals.
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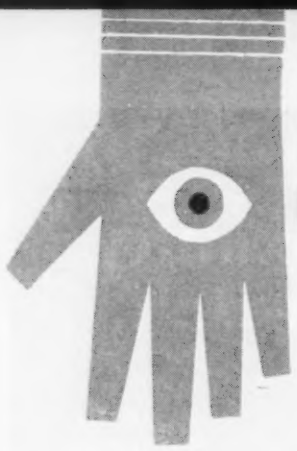


RESEARCH

GASEOUS OPTICAL MASER

Continuously-Operating Device Emits Highly Directional, Coherent Beam

Achievement of a continuously-operating optical maser, a goal long sought by many research laboratories, was announced by scientists at Bell Telephone Labs. In contrast to intermittent or "pulsed" optical masers, the new system takes a radically different approach, using a gaseous discharge to achieve continuous operation. Also, instead of being excited by a high powered flash of light, the gaseous optical maser receives its energy from an electrical discharge of very low power. The coherent beam of radiation lies in the infrared portion of the spectrum, and is thus invisible except through a "sniperscope" or similar converter.

Spectral line width of the output beam is a hundred thousand times narrower than that from other coherent light sources. This property has permit'ed the observation—for the first time—of difference-signals at radio frequencies between two optical lines. Beam of coherent radiation is highly directional, having a spread less than one minute of arc. A gaseous optical maser on earth, operating through a suitable telescope, could send a beam to the moon that would cover a spot smaller than one mile in diameter.

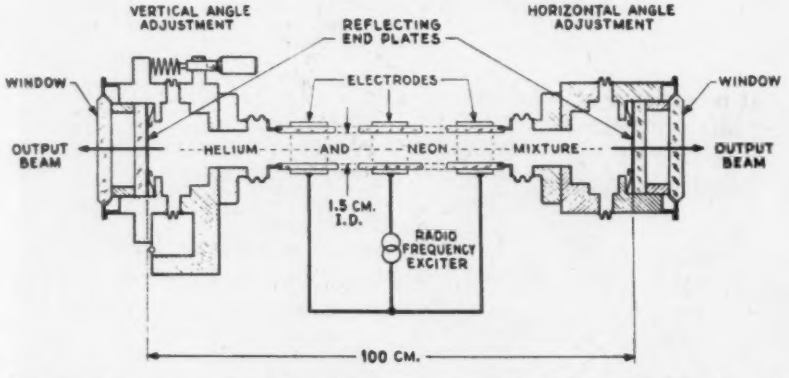


Fig 1 The gaseous optical maser developed by Bell Tel. Labs. Since neon atoms can radiate energy from almost any one of four upper energy levels to one of ten intermediate levels, up to thirty discrete frequencies can be emitted by the maser, depending on the specific mode of operation. The range of possible wavelengths lies between 9000 and 17,000 A. Present laboratory models have operated at five different wavelengths between 11,000 A and 12,000 A. Output line width is far sharper than that of ruby masers. The light emitted by the ruby devices is about 60 times narrower than the ruby's normal fluorescence. Normal fluorescence from the helium-neon mixture is already as narrow as that, and maser action narrows the beam more than one hundred thousand times more. Thus, the line is thousands of times sharper than the best spectroscopic lines available in the optical region. Other gas mixtures are expected to produce different frequencies with comparable success to that of the helium-neon mixture.

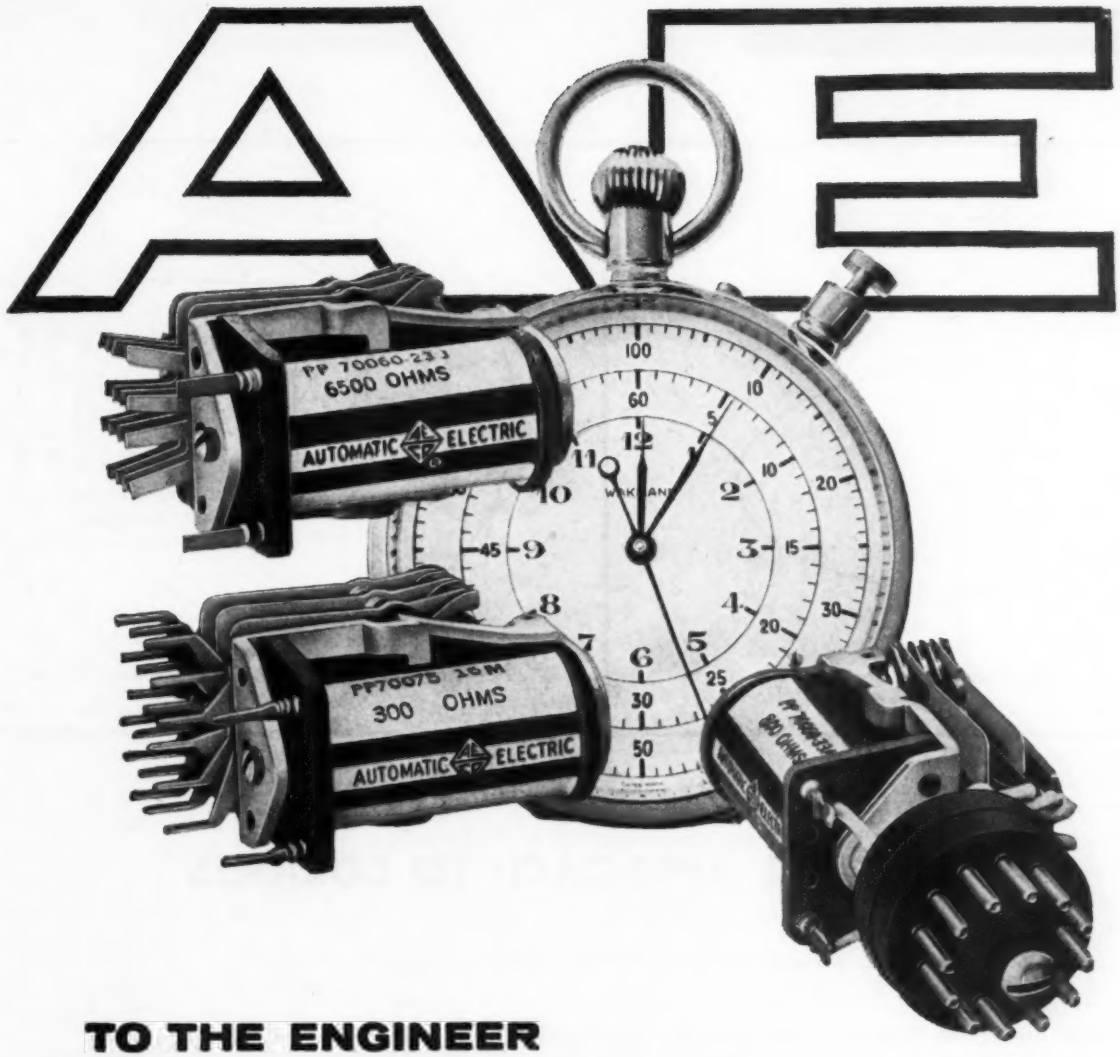
Ruby optical masers depend on an external bright light to "pump" chromium atoms in its crystal structure into an excited upper energy level. These excited atoms then emit their energy as coherent light. The gas maser uses a mixture of helium and neon gases through which an electrical discharge flows, in the same way as in a conventional neon tube. The energy from the internal discharge excites the helium atoms to a very high upper "metastable" energy level, from which they normally would not radiate energy.

The neon atoms in the mixture collide with the excited helium atoms, and the energy is transferred to them through the collision process. The neon atoms themselves then can be stimulated to radiate their energy on demand in a continuous stream. The beam is reflected back and forth through the length of the gas-filled tube, by semi-reflecting end plates, growing in intensity with each trip. Some of the beam is transmitted through the plates, and forms a very narrow output beam of coherent infrared light. During this stimulated radiation of energy, some of the neon atoms also drop into still lower energy levels, spontaneously emitting the reddish-yellow light typically associated with normal neon tubes.

The power required to excite the maser action is in the tens-of-watts range. The output power is in the 1/100th watt range. At this level of operation, the tube is so cool that it can be held in the hand without discomfort. The level of operation can be increased by using larger diameter tubes.

Optical gas masers and optical solid state masers are expected to complement each other in their applications. The latter maser, being essentially a high-power device, will have important uses even if limited to pulsed operation.

The gaseous optical maser should provide physicists with an immensely useful tool. The narrowness of the line will afford an accuracy hitherto unattainable in spectroscopic work at these frequencies. Another possible application of the new device is the measurement of distances of many miles with extreme accuracy. This new optical maser action, according to Bell scientists, is stimulating renewed interest in the whole field of gaseous-discharge physics. • • •



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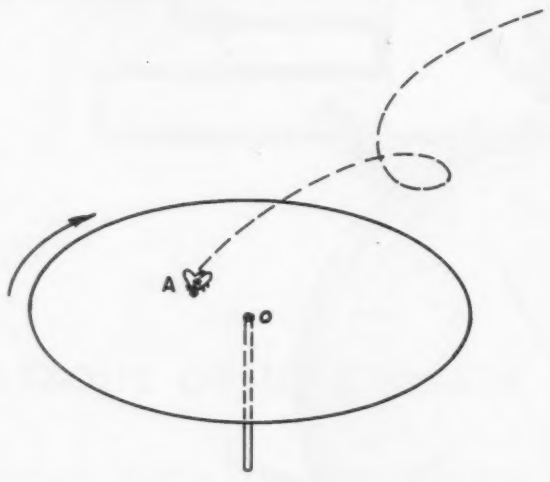

Fig 1 A fly lands on a rotating disc.

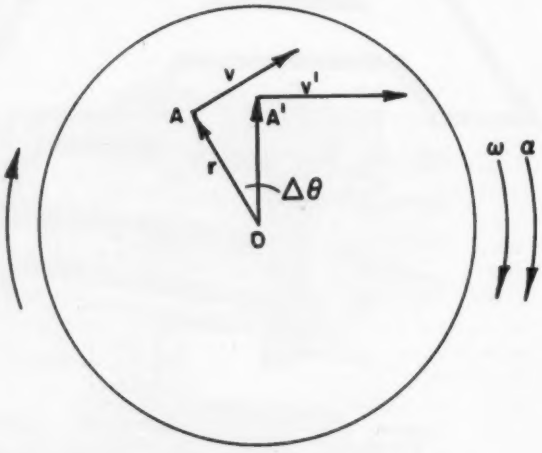

Fig 2a In time Δt, the disc rotates an amount Δθ.

A PHYSICAL APPROACH TO CORIOLIS

By L. J. Fangipane, *Kearfott Div., General Precision, Inc.*

In the latter part of the 19th century, a French mathematician, G. G. Coriolis, noted that whenever a body moves on a path that is rotating, a "supplementary acceleration" must be added to those that are more readily apparent. This component of the total acceleration has since been known as Coriolis acceleration, after its discoverer. The effects of this acceleration have been duly noted in the literature. Excellent articles have shown how everything that moves over the surfaces of the earth in the northern hemisphere veers to the right and in the southern hemipshere, to the left. Explorers lost in the snow show this tendency, and automobiles would show it if it were not for tire friction; freight cars would also but for the tracks which prevent sidewise drift.

With the development of high precision navigaton systems for aircraft and missiles, the effect of the Coriolis acceleration becomes an important design consideration. The purpose of this article is not to consider the effects of the Coriolis, but rather, by a simple illustration and a few vector diagrams, to explain the reason that the Coriolis component must be added.

First we must realize that both velocity and acceleration are vector quantities, i.e., they are made up of two parts: magnitude and direction. Whenever either the magnitude or direction changes, the vector quantity changes.

Keeping in mind also that acceleration is defined as a change in the velocity vector, let us first consider the absolute (total) acceleration of a body that is in a fixed position on a rotating platform. For example, suppose a fly lights on a disc as shown in Fig 1. We shall call this point A. Further, suppose the disc is rotating with an angular velocity of ω and an angular acceleration of α. Looking down on the disc, as in Fig 2a, we observe that the fly now has a linear (tangential) velocity v at a particular instant. This velocity is equal in magnitude to $r\,\omega$ and its direction is perpendicular to a radius r from O to A. A short time later he has been rotated through an angle $\Delta\,\theta$ to a new position and his velocity is v'. During this brief instant the fly's velocity changes in magnitude (due to the increase in ω) and in direction, due to the rotation.

Thus, in the vector diagram shown in Fig 2b, the change in velocity $\Delta\,v$ is seen to consist of two parts: RS and ST. RS is the change in velocity direction due to rotation; ST the change in magnitude due to α. If the time increment $\Delta\,t$, and consequently the angle $\Delta\,\theta$, become very small, we approach a limiting condition:

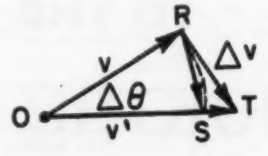

Fig 2b Change in vector velocity Δv is vector sum of RS and ST.

$$RS/dt = (\Delta\,v/\Delta\,t)_{rot} = (dv/dt)_{rot} = a_n,$$

where a_n = the normal component of acceleration, a direct result of the change in direction of the velocity vector, and

$$ST/dt = (\Delta\,v/\Delta\,t)_{acc} = (dv/dt)_{acc}\,\Delta = a_t$$

where a_t = the tangential component of acceleration. This component is present only when the disc has an angular acceleration or deceleration.

As long as the fly remains stationary on the disc, his total acceleration is the vector sum of these two components or

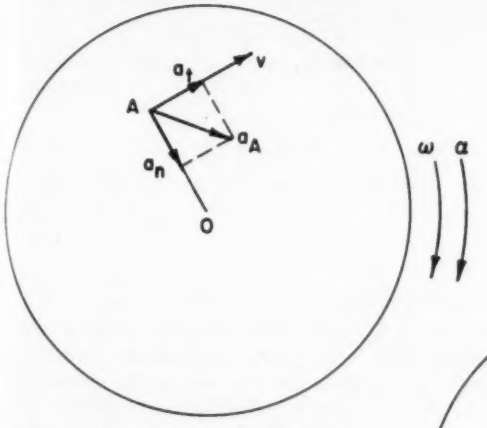

Fig 3 **Tangential acceleration a_t is parallel to tangential velocity. Total acceleration is vector sum of a_t and a_n.**

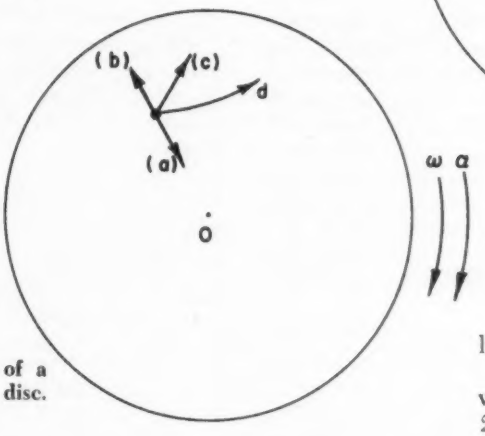

Fig 4 **The fly in motion can take any of a number of paths on the surface of the disc.**

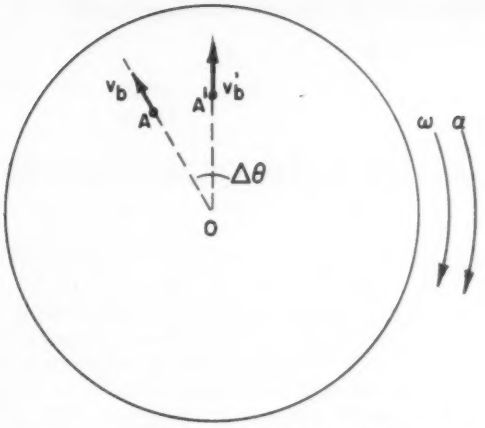

Fig 5a **Change in velocity vector of the fly moving with acceleration a_b ouwardly along a radial line of a rotating disc for time Δt. This motion includes a Coriolis acceleration term analysable into two parts as shown in 5b and 5c.**

$$a_A = a_n = a_t \qquad (1)$$

(In case of the earth, $a_t = 0$ and $a_A = a_n$)

Directions are as shown in Fig 3. It is worth noting that equation (1) can also be written explicitly as the sum of the radial (or centrifugal) and tangential accelerations.

$$\bar{a}_A = \bar{r\omega}^2 + \bar{r\alpha} \qquad (2)$$

Now, the fly can move with respect to the disc from his position at A. There are several possible paths he can take. For instance, as shown in Fig 4, he can move radially inward (a) or outward (b); he can walk straight along at some angle (c) or he can trace out a curved path (d). Regardless of the path chosen, his motion will introduce the supplementary acceleration observed by Coriolis.

Let us choose one of the simpler paths, that labeled (b), for purposes of our explanation. Should the fly move radially outward from point A at a velocity v_b and acceleration a_b, both relative to the disc, one might expect the total acceleration to be

$$a = a_A + a_b \qquad (3)$$

This equation, we will show, is incomplete, since it lacks the components of Coriolis acceleration.

To see where these components come from, let us look more closely at what happens when the fly walks outward along path (b). Actually, because the path is rotating, two things happen simultaneously which effect his velocity (see Fig 5).

1. First, as the disc rotates through $\Delta\theta$, v_b changes its direction in space. In the short time Δt, this change must be equal to $v_b\,\Delta\theta$ (Fig 5b), so that as Δt approaches zero, the limit is

$$v_b\,\Delta\theta/\Delta t = v_b\,d\theta/dt = v_b\omega \qquad (4)$$

This is the portion of Coriolis acceleration due to the change in direction of v_b. The direction of this portion is perpendicular to that of v_b.

2. Secondly, as the fly moves outward along (b), the radial distance from 0 is increased by an amount dr in a time dt. This changes the tangential velocity $r\omega$ discussed earlier and gives us the second half of the Coriolis acceleration (See Fig 5c). The new tangential velocity would be $v = \omega(r + dr)$. The change alone would be $\omega\,dr$. For the time dt this term would be written $\omega\,dr/dt$. But dr/dt is another way of stating v_b. Accordingly,

$$\omega\,dr/dt = \omega v_b, \qquad (5)$$

which is exactly the same as the previous portion, (4). Its direction is likewise perpendicular to v_b.

Adding these two portions together, we get a total Coriolis component of $2v_b\omega$ which is the amount we must add to the right side of equation (3). Our final equation then, for the absolute acceleration of the fly is

$$a = a_A + a_b + 2v_b\omega \qquad (6)$$

Thus we see that Coriolis acceleration is a direct result of the rotation of the "world" of the fly. We used a very simple case rather than the general one to avoid obscuring the derivation with additional terms. In the case of the Earth, $\omega_E = \omega\sin\lambda =$ angular velocity of the Earth (15°/hr) times sine of latitude.

It is worth noting that the motions of the air over the earth are governed, to an appreciable extent, by the Coriolis effect. The correction for this effect in the navigation of a ship or plane by celestial navigation may amount to several miles if, for example, the bubble octant is used in the necessary observations. In present day automatic guidance systems, a correction for Coriolis acceleration is automatically calculated and fed into the system computer. • • •

Fig 5b **Part of Coriolis acceleration due to change in direction of velocity vector.**

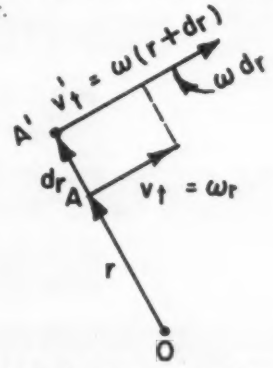

Fig 5c **Part of Coriolis acceleration due to change in magnitude of velocity vector.**

SQUARE ROOT OF A COMPLEX NUMBER

By Harvey Karp, *Secure Electronic Engrg, Inc., Newton, Mass.*

Finding the square root of a complex number is a frequent operation in electromechanical engineering mathematics. The usual procedure is to convert to either polar or exponential form. However, if the original data is in rectangular coordinates and the answer is desired in rectangular form, the intermediate conversion steps are undesirable. Here is a method that reduces the task to a convenient slide rule operation, eliminating the need for coordinate conversion.

The square root of a given complex number, $(a + jb)$, is of the form $\pm (c + jd)$. The magnitude of c and d can be determined by substituting in the following equations:

$$c = \pm\left[\frac{(a^2 + b^2)^{1/2} + a}{2}\right]^{1/2}$$

$$d = \pm\left[\frac{(a^2 + b^2)^{1/2} - a}{2}\right]^{1/2}$$

The above two formulas, which can handle any complex number in rectangular form, are derived in Table I. The form, $\pm (c + jd)$, is also the square root of $(-a + jb)$, however, if the given number is $(-a-jb)$ or $(a-jb)$, then the square root is $\pm (c-jd)$.

As an illustration of the use of the above formulas, consider a transmission line with series and shunt constants, Z and Y. Correct termination for the line is its surge impedence, $Z_o = (Z/Y)^{1/2}$. Suppose that at a particular frequency:

$$Z_o = 10^2\,(8.1 - j1.9)^{1/2}$$

The square root is found by substituting in the equations for c and d:

$$c = 10^2\left[\frac{(8.1^2 + 1.9^2)^{1/2} + 8.1}{2}\right]^{1/2} = 286.5$$

$$d = 10^2\left[\frac{(8.1^2 + 1.9^2)^{1/2} - 8.1}{2}\right]^{1/2} = 33.15$$

Since the original number was in the fourth quadrant, its square root must be in either the second or fourth quadrant. From physical considerations, the second quadrant root is extraneous, since the resistive component must be positive. Therefore, $Z_o = 286.5 - j33.15$. • • •

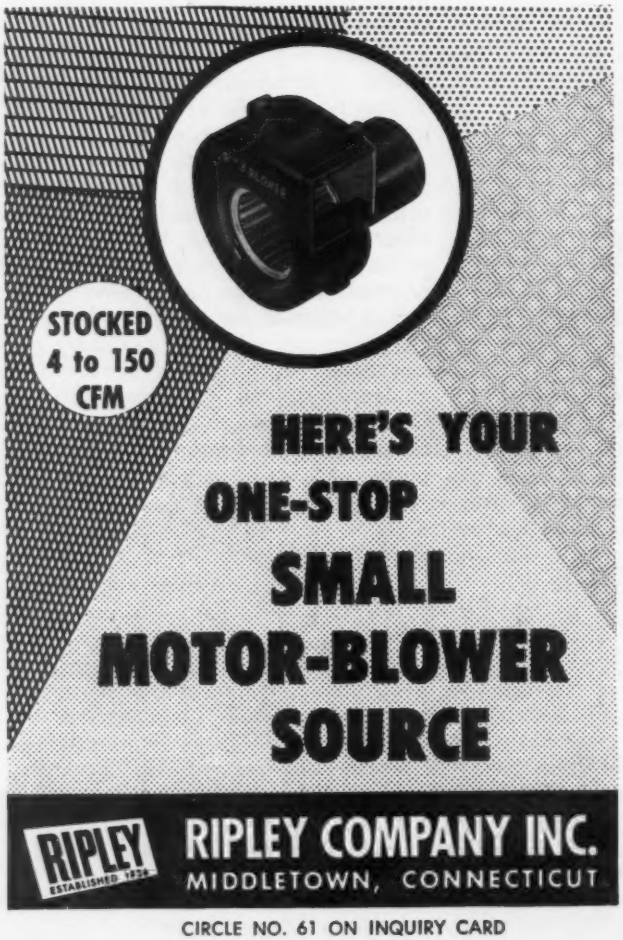

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TABLE I

Find The Square Root of $a + jb$

Let $(c + jd) = (a + jb)^{1/2}$, where a, b, c, and d are real numbers.

$$1.\ (c + jd)^2 = a + jb$$

$$2.\ c^2 + j2cd - d^2 = a + jb$$

Since the real and imaginary components must be equal in an identity, then:

$$3.\ b = 2cd$$

$$4.\ a = c^2 - d^2$$

Substitute the value of c from 3 into 4.

$$5.\ a = \frac{b^2}{4d^2} - d^2 = \frac{b^2 - 4d^4}{4d^2}$$

Rearrange in descending powers of d^2.

$$6.\ 4(d^2)^2 + 4ad^2 - b^2 = 0$$

Solve for d^2 by the quadratic formula

$$7.\ d^2 = \frac{-4a \pm (16a^2 + 16b^2)^{1/2}}{8} = \frac{-a \pm (a^2 + b^2)^{1/2}}{2}$$

$$8.\ d = \pm\left[\frac{-a + (a^2 + b^2)^{1/2}}{2}\right]^{1/2}$$

Note: since all the parameters must be real numbers, and $(a^2 + b^2)^{1/2} > a$ or b, the negative sign before $(a^2 + b^2)^{1/2}$ is a spurious answer.

Substitute 7 into 4:

$$9.\ c^2 = a + \frac{-a + (a^2 + b^2)^{1/2}}{2} = \frac{a + (a^2 + b^2)^{1/2}}{2}$$

$$10.\ c = \pm\left[\frac{a + (a^2 + b^2)^{1/2}}{2}\right]^{1/2}$$

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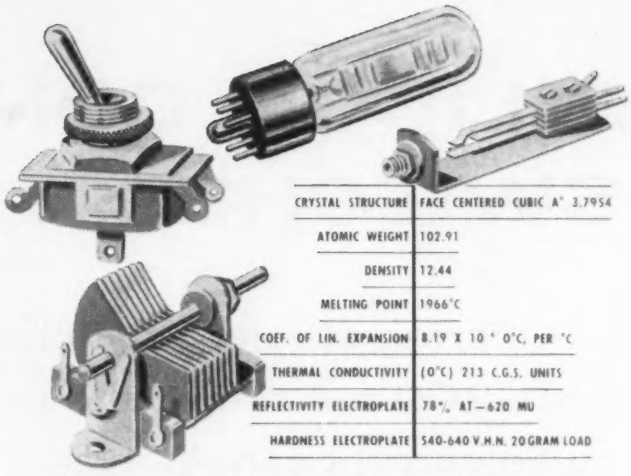

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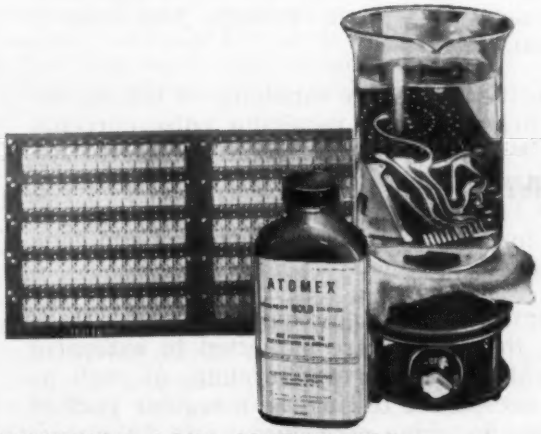

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2N885	30	200	20	.44	.60
2N886	60	200	20	.44	.60
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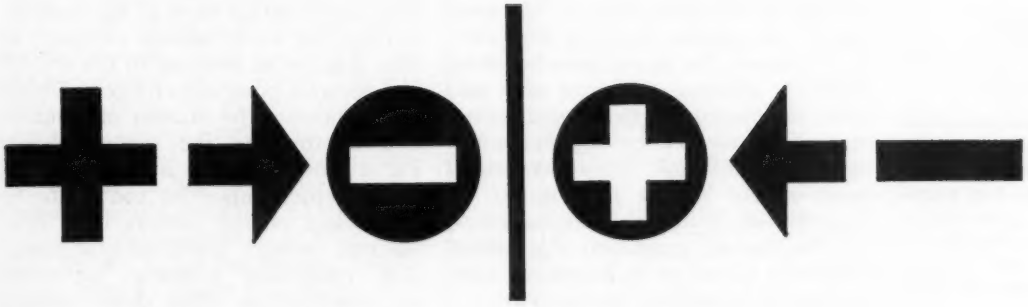

SEMICONDUCTOR DEVICES
in Electromechanical Engineering – Part II

This second part of Components Digest 21 is a brief, non-mathematical discussion of solid-state theory, intended to provide the electromechanical engineer the minimum background he needs to understand how semiconductors work and the factors affecting their performance.

Semiconductors are crystalline solids with electrical conductivity intermediate between the conductivities of metals and insulators. They constitute the basis of a wide variety of devices. Thermistors (temperature sensitive resistors) and varistors (voltage sensitive resistors) are common examples. Semiconductor devices may be used to rectify (diode) or to amplify (transistor). Light-sensitive, strain-sensitive, magnetic-field sensitive semiconducting devices and others are being developed and are finding increasing application.

In a crystalline solid, atoms combine into a regular array called a crystal lattice. In individual atoms, the electrons each have certain energies in accordance with quantum theory. We say there are energy levels occupied by the individual electrons of the atom. The energy levels are characteristic of the atom. As atoms approach one another as within a crystal lattice the electrons in the outer shells begin to ineract, altering their energy. As a result of this interaction, energies of individual electrons in the outer shells may have a wide range of values rather than the few discreet values characteristic of the electrons in individual atoms; a sharp energy level is fanned out into a range of possible levels called a band. Band formation at the interatomic distances of crystals is most prominent for the outer or valence electrons. When the energy levels have spread into bands, the valence electrons may move from atom to atom with an ease that increases with increasing width of the band.

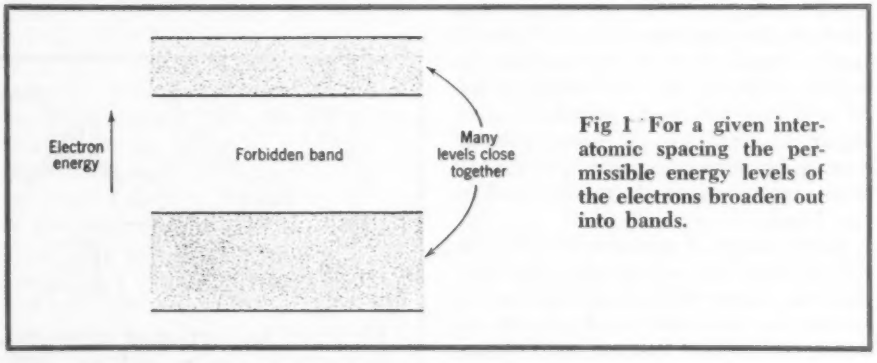

Fig 1 For a given interatomic spacing the permissible energy levels of the electrons broaden out into bands.

The bands of possible electron energy levels in a solid are called allowed energy bands. There are also "forbidden" bands or gaps (Fig 1) which result directly from the discreet energy levels that characterize electrons in atoms, quantum properties that have no analog in classical mechanics. An electron cannot be in a forbidden band. Permissible energy bands sometimes overlap and sometimes are separated by forbidden bands.

In a semiconductor, the highest electronic energy band that can be filled with electrons is called the valence band. The electrons in the valence band are the valence electrons that bind the crystal together. The valence band in a semiconductor is completely filled at very low temperatures where the thermal energy is not sufficient to jump electrons across the gap to the next higher energy band. This next higher band of permissible energy levels is called the conduction band because electrons that contribute primarily to conduction are at these energy levels.

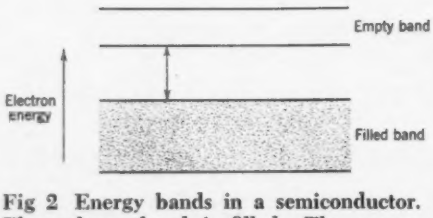

Fig 2 Energy bands in a semiconductor. The valence band is filled. The energy gap to the empty band is small so that some thermally excited atoms can reach the empty conduction band, providing a conductivity intermediate between metals and insulators where there is a large energy gap from the filled valence band to the conduction band.

At low temperatures in semiconductors the conduction band is empty, but at higher levels of thermal excitation some valence electrons obtain sufficient energy to reach an energy level in the conduction band (Figs 2 and 3). The number of conduction electrons as a result of thermal excitation is normally small compared with the number of energy levels in the conduction band. As we shall see later, introduction of impurity atoms into a semiconductor crystal also influences raising the energy level of some electrons to the conductive band.

When some of the electrons of the valence band are missing, the remaining electrons may redistribute themselves among the available energy levels, as under an applied electric field, effectively giving rise to an electric current. The net effect of this process is equivalent to that of particles equal in number and similar in motion to the missing electrons but behaving as if positively charged. These equivalent particles are called holes. Thus, conduction in a semiconductor results from the movement of electrons and holes in an applied electric field.

A semiconductor in which the concentration of charge carriers is characteristic of the material itself rather than a function of impurity content or structural defects of the crystal, is called an *intrinsic* semiconductor. Electrons in the conduction band and holes in the valence band are created by thermal excitation of electrons from the valence to the conduction band, thus leading to equal concentrations of electrons and holes.

IMPURITY SEMICONDUCTORS

As remarked previously, a semiconductor exhibits a conductivity lying between the conductivities of conductors and insulators. At low temperatures, the valance band is full. Heating will provide energy to permit an occasional valence electron to escape the atom and move about in the crystal by lifting its energy level through a forbidden band to the next higher permissible level in the conductive band. The parent atom becomes positively charged, and can now acquire an electron from a neighboring atom. We have in effect a limited number of electron-hole pairs permitting some current flow in response to an electric field. With increasing temperature the thermal generation of electron-hole pairs occurs at an increasing rate leading to increasing conductivity.

The conductivity of a semiconductor material may be substantially increased by adding even a trace of impurity to the semiconductor crystal. If a small proportion of certain impurity atoms is introduced into the semiconductor crystal during its formation, these atoms will disperse throughout the crystal, taking the place of some of the semiconductor atoms. An *acceptor* impurity atom is one which substitutes for a regular atom of the material but has one less valence electron. These atoms accept or take up electrons from the crystal and become negatively charged. Acceptor atoms increase the number of holes in the semiconductor. Atoms of aluminum, gallium or indium are acceptors in germanium and silicon semiconductors. Analogously, a *donor* impurity atom in a semiconductor substitutes for a regular atom of the material but has one more valence electron. It thus donates an electron to the crystal and becomes positively charged. Donor atoms increase the number of conduction electrons in the semiconductor. Fig 4 shows the way in which donor and acceptor impurities contribute to the mobile charge carriers of a germanium crystal. Semiconductor materials containing acceptor impurities are called p-type, while those containing donor impurities are called n-type. The names represent the "positive charges" of the holes, and the negative charges of the electrons. The presence of donor or acceptor impurities unbalances the proportion of positive to negative charge carriers. The type of charge carriers in larger concentration in the material is called the majority carrier; and the type in smaller con-

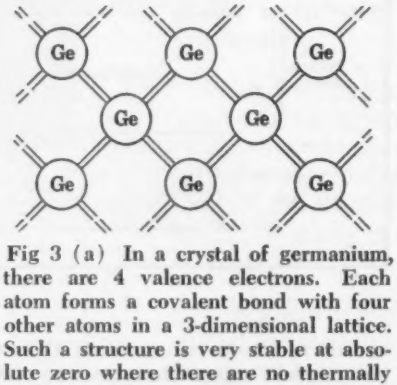

Fig 3 (a) In a crystal of germanium, there are 4 valence electrons. Each atom forms a covalent bond with four other atoms in a 3-dimensional lattice. Such a structure is very stable at absolute zero where there are no thermally excited conduction electrons or holes.

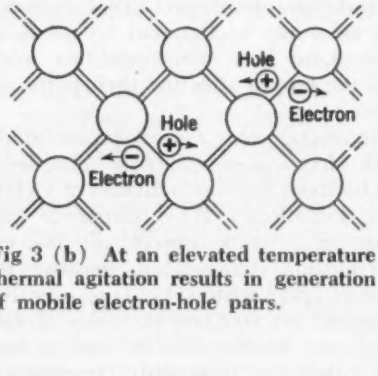

Fig 3 (b) At an elevated temperature thermal agitation results in generation of mobile electron-hole pairs.

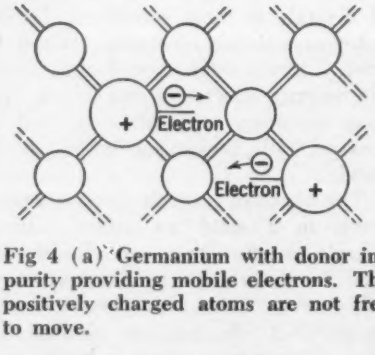

Fig 4 (a) Germanium with donor impurity providing mobile electrons. The positively charged atoms are not free to move.

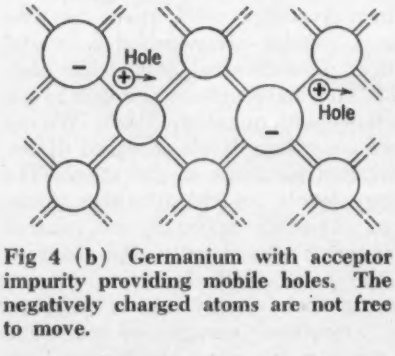

Fig 4 (b) Germanium with acceptor impurity providing mobile holes. The negatively charged atoms are not free to move.

centration is called the minority carrier.

EFFECT OF TEMPERATURE

When semiconductors whose conductivities largely depend upon the nature and concentration of impurities are raised to a sufficiently high temperature, the intrinsic carrier concentration (thermally generated electron-hole pairs) becomes so large that the effects of impurity atoms may become comparatively small. There may be a range of temperature within which the impurity atoms in the material are practically all ionized, supplying a maximum number of carriers. Within this "exhaustion" range, the carrier concentration is nearly constant. At very low temperatures the electrons or holes supplied by the impurities become bound to the impurity atoms and the conduction carrier concentration decreases rapidly with further temperature decrease.

To summarize, holes or electrons in a crystal originating from donor or acceptor impurities, or from the thermal generation of electron-hole pairs, may move about under the influence of an electric field to provide conduction. The properties are established during manufacture of the crystal, where the type (p or n) and conductivity are controlled by the addition of controlled amounts of impurities.

Carriers move through a semiconductor by *diffusion* or *drift*. Diffusion occurs as a result of non-uniform concentration of the carrier. Superimposed on the random thermal motion of the carrier is a general tendency to move from regions of higher concentration to regions of lower concentration; thus tending to even out any local concentrations. Drift on the other hand occurs in response to a potential gradient within the semiconductor, causing holes and electrons to move with or opposed to the electric field respectively. If a battery is applied to n-type germanium, electrons will flow in the direction of the positive terminal; while for p-type germanium, holes will flow toward the negative terminal.

P-N JUNCTION

A p-n junction is formed when a p-type and an n-type semiconductor are in intimate contact. Consider what happens at the junction. Since the p-region exhibits a high concentration of holes while the n-region exhibits a high concentration of electrons, there will be a density gradient due to the localized concentrations on either side of the junction. Holes will diffuse to the n side and electrons will diffuse to the p-side. There is a net motion of positively charged holes and negatively charged electrons across the junction. An electric field is set up in the hitherto electrically neutral material, the n-type material with a net excess of holes becomes positive, while the p-type material with its excess of electrons becomes negative. This potential gradient occurs in the immediate vicinity of the junction, and causes a drift current of the mobile carriers, in which the holes move in the same direction as the field, and the electrons in the positive direction. Drift currents are therefore set up in the opposite direction to the diffusion currents. Eventually an equilibrium is reached where diffusion and drift currents exactly balance. The width of the transistion region where potential changes in the vicinity of the junction is of the order of 10^{-4} cm. Outside of this region, the semiconductor materials are unaffected, and behave as if the two types were separated. A contact potential of the order of tenths of a volt may appear across the junction, the n-type region being the more positive.

Now assume that a potential difference is applied across the junction to make the p-type region more positive, Fig 5 (a). Holes in the p-type region are attracted by the negative potential at the n-type region, and vice versa for the electrons in the n-type region. As holes and electrons cross the junction in response to the externally applied field, they recombine with the majority carriers on the opposite sides of the junction. The p-region acquires a net negative charge, whch is balanced out by the flow of holes from the battery or other source of applied electric potential. The n-region acquires a net positive charge, requiring a flow of electrons from the battery. The total current across the junction is the sum of the hole and electron currents, since although they flow in opposite directions, they have opposite signs. The conventional current is in the direction of hole flow, from the p-region to the n-region, when the p-region is made more positive. Depending on the reserve of majority carriers in each region, a small increase in externally applied potential can lead to a considerable current increase.

Now reverse the polarity of the applied potential, Fig 5 (b). Holes will tend to flow from the n-region to the p-region, and electrons the other way. However, the concentrations of these minority carriers is relatively low, and conductivity is consequently very poor. As the applied potential is increased, the flow of holes very soon reaches a limit, as does the flow of the relatively few electrons in the p-region. A current saturation sets in.

From the above description, we see that the p-n junction acts as a rectifier, permitting a substantial current flow when the p-region is biased positively with respect to the n-region, and a small quickly saturating current flow when

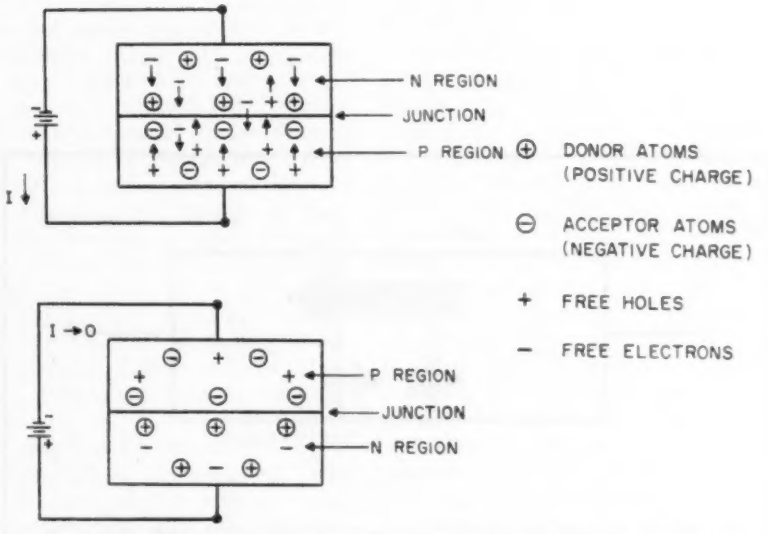

Fig 5 Conduction in a p-n junction. Fig 5 (a) shows a forward biased condition, while 5 (b) shows a reversed biased condition.

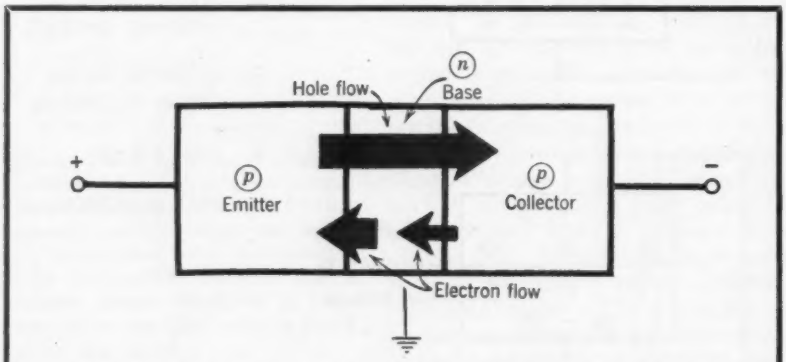

Fig 6 Rough picture of the flow of holes and electrons in a normally biased p-n-p transistor. The base is grounded for convenience. The electron flow is essentially due to mobile minority carriers resulting from thermal excitation. The holes reaching the collector are less than those leaving the emitter due to some recombination in the base.

the p-region is biased negatively. This reverse saturation current is of particular importance in respect to the power-handling capability of a rectifier. Silicon exhibits a lower current than germanium.

As reverse voltage is increased, a critical junction breakdown voltage is reached, beyond which a sharp increase in conduction take place. This phenomenon may be thought of as an avalanche process, or a mechanism of electron multiplication by collision. A free electron in the p-region, under the influence of the applied inverse field may be accelerated sufficiently in the vicinity of the junction so that when it collides with a fixed electron it can set it free. The pair of electrons, still undergoing acceleration, continue the collisions, increasing the number of free electrons rapidly by this multiplication process. The voltage across the junction tends to remain constant, which has led to the application of this breakdown phenomenon in Zener diodes as a source of relatively constant voltage. When dissipation is properly limited, the breakdown results in no damage to the semiconductor.

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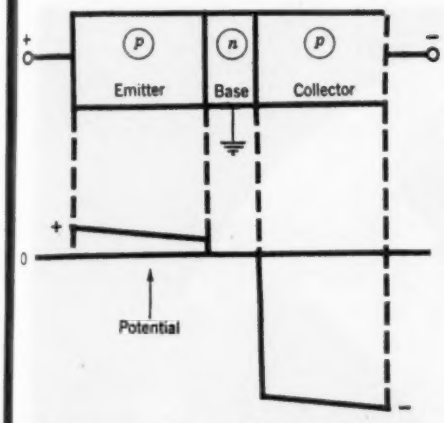

Fig 7 Potential distribution in normally biased p-n-p transistor.

THE P-N-P TRANSISTOR

Up to this point we have considered the simple p-n junction, observing that it has rectifier charactertistics. Suppose we reduce the n-region in thickness so that it extends very little beyond the junction, and we attach an individual p-region to the outside edge, providing an n-p junction. If the original p-n junction is energized in the conducting direction, the n-region is sufficiently small so that very few of the holes have time to recombine with electrons in the n-region before reaching the new n-p junction. Now suppose we bias this second n-p junction in the non-conducting mode. All the holes which have managed to cross the n-region and into the second p-region without recombining are drawn into this p-region because of the negative (non-conducting) potential applied there.

This arrangement, capable of providing amplification, is called an p-n-p transistor, Fig 6. The n-region is called the *base*, the positively energized p-region the *emitter* because it emits holes to the bases; while the negatively biased p-region which collects holes reaching it from the base is called the *collector*.

Obviously, on the basis of the previous description, electrons will flow from the base to the emitter. This electron flow does not provide transistor action since there is no link with the collector. To minimize this useless electron flow, the conductivity of the base (a measure of the concentration of mobile carriers) is made much lower than the conductivity of the emitter. The emitter has a generous supply of mobile holes. An electron flow occurs from collector to base, but this flow is very small because the collector is reverse-biased.

We might say a few additional words about current flow in the transistor base region. Fig 7 shows an approximate picture of how potential is distributed between emitter and collector in a typically biased p-n-p junction transistor. Note that the drop across the base region is very small, too small to move the hole current from emitter to collector across the base region. Actually current flow across the base region takes place by diffusion. The forward biased emitter-base junction provides to the base a steady supply of holes, which in the course of this spreading out reach the second n-p junction, and the collector.

In our next installment in this series we consider how the above physical description leads to an understanding of the performance characteristics of transistors and rectifiers. We then consider a number of different types of transistors, tabulating their distinguishing characteristics. • • •

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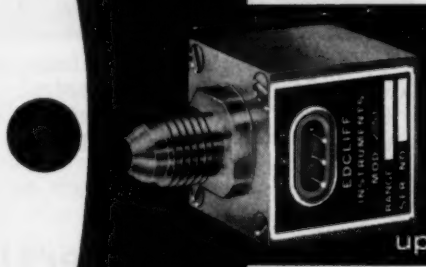

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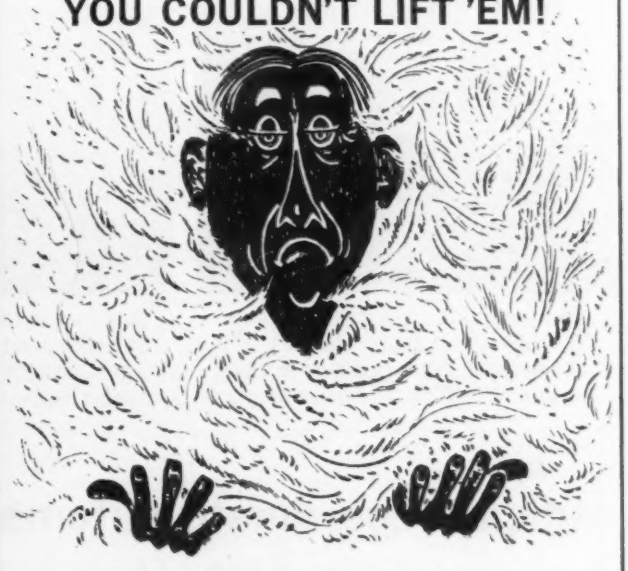

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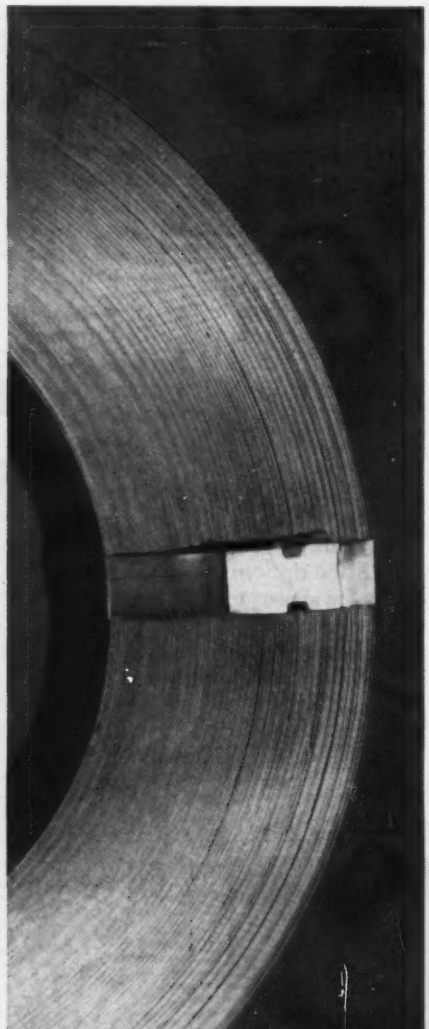

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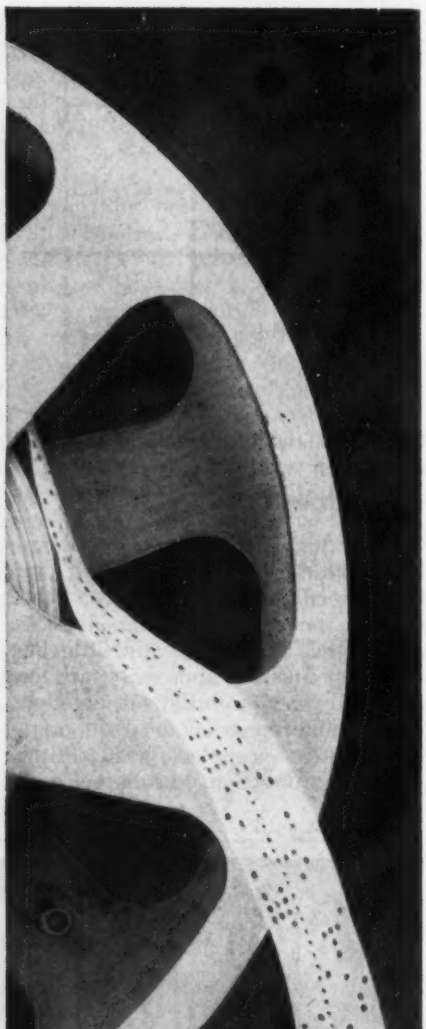

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COMPONENTS DIGEST 1

SERVOMOTORS-Part II

GEARHEAD SELECTION

Since servomotors operate most efficiently at much higher speeds than are required to drive transducer loads, practically all electromechanical instrument servomechanisms use reduction gearing between the servomotor and the transducer it actuates.

This natural association of servomotor and gearing makes it practical to combine motor and gearhead in a single compact assembly with resultant simplification in servomechanism packaging as well as gains in reliability and cost reduction.

The advantages of standard motor gearheads summarized in Table I have led to the almost universal practice in the design of miniature servomechanisms of employing gearheads which match the frame sizes of the Standard Bureau of Ordnance servomotors. Thus, a Size 11 gearhead couples to a Bureau of Ordnance Size 11 servomotor and may be mounted in the standard manner. This practice extends also to motor tachometers.

GENERAL CONSTRUCTION OF A GEARHEAD

Two jig-bored parallel bearing plates provide the bearing seats for the various gear shafts in the gearhead. The shaft centers are symmetrically located on a circle concentric with the axis of the gearhead. Gear clusters are selected to give the required ratio, always using the same shaft centers.

Flanged bearings provide true alignment of shafts. The pinions and gears may be fabricated from materials having different grades and hardness, such as 416 and 303 stainless steels, to obtain the best combination for required wear characteristics.

Aluminum is the most commonly used gear housing material. A gearhead motor with an aluminum housing mounted on an aluminum heat sink plate (a typical installation) has a much lower temperature rise than a similar unit with a steel housing, because aluminum is much more efficient at conducting heat.

Gearheads often incorporate slip clutches to protect the output shaft against a stalled condition where damaging shaft torques might be developed.

The following sections consider in turn the factors of importance in specifying the performance characteristics of gearheads required for specific applications.

This article is based on information being prepared for a special handbook section of a catalog on gearheads and speed reducers by Superior Manufacturing and Instrument Corp. For the complete catalog, write No. 229 on the Inquiry Card, or write directly to the company at 36-07 20th Ave., Long Island City 5, N. Y.

PERFORMANCE FACTORS IN GEARHEAD SELECTION

Performance characteristics of a gearhead are best established by comparing the required characteristics with those of a hypothetical ideal gearhead. The ideal gearhead would provide an output shaft speed exactly proportional at any instant to input shaft speed, the proportionality factor being the gear ratio. There would be no friction (other than reflected load friction) at the input shaft, nor would the gear train introduce any inertia. Resilience of shafts and gear teeth would be negligible and backlash would be zero. And these idealized features would be retained at full output load over the life of the unit.

GEAR RATIO

Choice of gear ratio is made by the servomechanism designer. The important consideration here is whether the ratio is selected on the basis of matching motor to load, or whether ratio is determined by considerations of loop gain. Table II summarizes some of the factors influencing the choice of gear ratio. Ample margin should be provided to account for variations in servomotor characteristics.

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COMPONENTS DIGEST

Once the overall ratio is established, the gearhead manufacturer matches this as closely as possible with one of his standard models. For this reason some tolerance is necessary on the specified ratio. An "exact" ratio requirement, calling for a non-standard gear design, costs more than an approximate yet suitable ratio. Timing devices driven by synchronous motors, and integrating motor tachometers, however, often require exact ratios.

BACKLASH

In general, it is the backlash at the output shaft of the gearhead that is of interest to the designer. It is here that backlash may be most readily related to the feedback transducer (control transformer, potentiometer, etc.) In effect, backlash introduces a kind of time delay in that portion of the servomechanism between the servomotor and the response signal of the transducer. As with all time delays, backlash tends to introduce an instability factor in the servomechanism loop which the design engineer is often apt to overlook. A servomechanism which on paper appears to be perfectly stable may exhibit the characteristic high-frequency low-amplitude oscillation or "buzz" resulting from backlash. Even though backlash oscillations may be very small in amplitude, perhaps well within permissible accuracy limits, they may introduce excessive equipment wear, particularly on the gear teeth. Gearheads with backlash of 30 minutes or less generally satisfy most requirements in practical servomechanisms.

Unfortunately the tendency to oscillate is greatest in servomechanisms with the least static friction, namely those where highest sensitivity is required. Static friction is probably the best deterrent to backlash oscillations even though it is not a reliable or effective means to employ systematically. It is a mistake to tighten gear meshes so as to introduce excessive static friction (as well as static inaccuracy) since the meshes eventually loosen as a result of wear, also, because of eccentricities which inevitably occur in the most accurate gears, some mesh points will always be looser than others, which may lead to sporadic oscillations. Similar remarks might be made about intentional use of excessively preloaded bearings.

The best way to deal with backlash is to provide accurate gear meshing together with a means of damping sufficient to assure that oscillations do not occur when servo gain is increased to the required design value. Inertially damped motors are particularly effective in critical backlash situations.

The factors which must be considered in setting a specification for backlash are:

- Backlash at the feedback transducer must be consistent with overall accuracy requirements;
- Backlash must be small enough so that the tendency to oscillate is eliminated. Servos with high velocity constants and long motor time constants are most sensitive to backlash as are also high-sensitivity servos where static friction is an absolute minimum;
- Backlash may be relatively unimportant in servomechanisms that drive a friction load at a uniform or slowly varying velocity;
- Backlash is of less importance where the output transducer swings through a wide angle (such as with a multiturn potentiometer).

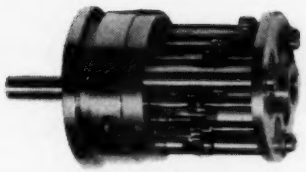

TABLE I
Advantages of Standard Gearheads

1. Simplify design and packaging of servomechanisms and systems.
2. Achieve more uniform performance, saving much costly and complex assembly.
3. Lower cost as a result of mass production and standardization of gearhead.
4. Proven performance, based on use of standard item.
5. Environmentally tested, frequently in diverse applications. Closed construction affords convenient protection.
6. Changes, including ratio changes, may be readily accomplished in early stages of prototype testing.

TABLE II
Gear Ratio Selection

1. When the reference signal varies at a relatively constant speed, the gear ratio should permit following at this speed.
2. When the reference signal experiences sudden increments (high acceleration) the gear ratio should be selected to achieve maximum torque-to-inertia ratio at the output.
3. Where static accuracy of slow smooth following is a principal consideration, the gear ratio should amplify motor torque so that the output torque is capable of maintaining the error within allowable limits. The gear ratio is usually inefficient in terms of power transfer to the load.
4. When there are special requirements such as the ability to maintain simultaneously a specified velocity and acceleration, or the need for rapid reversal, or the requirement of minimum time to come up to speed, or a maximum allowable braking time, the gear ratio must be determined accordingly.
5. When a specified friction load is to be carried at a given speed, (either a constant friction or a linear speed-varying drag), the gear ratio should suitably match the motor maximum power output point to the load speed.

SPEED AND TORQUE RATINGS

Speed and torque ratings are of course determined by requirements of wear and life. In many applications, loads are negligible and life of several thousands of hours is readily achieved under the more common military environments. In such instances it is necessary only to make certain that loading is not introduced as a result of improper gear installation; for example, cocking, eccentricity, or similar misalignments may cause heavy wear, even without output shaft load.

At the input end, coupled to the drive motor, little difficulty is encountered at speeds to 12,000 rpm. Fortunately, most common 400-cycle servomotors have no-load speeds under 7,000 rpm, or occasionally 10,000 rpm. Sixty-cycle motors have much lower speeds. D-C motors occasionally reach speeds of 18,000 rpm, and care must be exercised to insure adequate life, especially if appreciable torque loads occur. Because of the high speed and low torques encountered at the motor end of the gear train, relatively loose meshes and fine pitch gearing are commonly employed.

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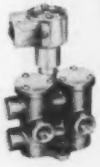
MOMENTARY CONTACT solenoid-pilot valves



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COMPONENTS DIGEST

At the low-speed end, on the other hand, substantial torques may occur, even in very low power systems. A Size 8 motor with a rated stall torque of 0.25 ounce-inches generates approximately 75 ounce-inches through a rather typical 300:1 reduction ratio. Under running conditions the teeth must withstand surface fatigue and bending stresses for the required life of the unit. The choice of gear materials and their heat treatment, as well as the selection of pitch and face width determine the loading capacity. The gears must be cut accurately, aligned properly and permanently fastened to their shafts to insure full use of their inherent load-carrying capacity.

BEARINGS

Gearhead designers are quite restricted by packaging design in their choice of bearings. Generally speaking, Class 5 and Class 7 stainless steel ball bearings provide best life as well as best performance. Their major disadvantage is their high cost, especially in gearheads with multiple meshes and, hence, many bearings.

If price is of importance and the application requirements are somewhat less critical, sleeve bearings may be profitably used. These generally exhibit higher friction and poorer life than ball bearings, particularly under extreme temperature conditions. To be useful, sleeve bearings must be machined to extremely close tolerances and carefully installed, otherwise wear becomes excessive and premature failure occurs.

LUBRICATION

The problem of lubrication applies to gearhead bearings just as it applies to the servomotor bearings. Lubricants must be selected on the basis of ability to operate at extreme temperatures without introducing excessive viscous friction even at low temperatures, where the servomotor-gearhead combination must still respond readily to small signals.

GEARHEAD FRICTION

Gearhead friction is undesirable for two reasons: (1) it may result in appreciable power loss in the gearhead, particularly where the load draws high power, and (2) it reduces the sensitivity of the servo loop, often directly affecting the static accuracy. In precision instrument servo loops, friction torque amounting to only several thousandths of an ounce-inch assumes significance.

Higher gear friction than would ordinarily be acceptable may be unavoidable in applications where heavy grease is used, perhaps to meet some very high temperature requirement. Such greases often introduce disturbing amounts of friction at very low temperatures, and the selection of grease must be made with great care, often with experimental verification of the low temperature starting characteristics of the motor-gearhead assembly. Sometimes a permissible warm-up time is specified, during which the grease temperature increases as a result of heat generated by the servomotor until the required starting and no-load speed characteristics are achieved.

INERTIA

Inertia introduced by the gearhead should be inappreciable by comparison with the servomotor inertia if the motor's

acceleration characteristics are to be utilized. This is usually not a difficult design problem and is best solved by using a pinion cut directly in the motor shaft at the input drive, and by avoiding large ratios in the first stage or two of the train. The slower shafts contribute practically nothing to the overall reflected inertia at the motor shaft.

MISCELLANEOUS APPLICATION FACTORS

Where application requirements call for accuracies, torque ratings, or special mechanical features not included in the standard gearhead construction, it is general practice to provide additional gearing driven by the gearhead output shaft. These gears are larger than the gears within the gearhead, although for ease of installation their diameter rarely exceeds the gearhead diameter.

These larger additional gears may be designed for exceptionally high accuracy, high torque capacity, or tightness of mesh. Spring-loaded gears may be installed if required. Ultimate positioning accuracy of ± 1 minute may be achieved to drive resolvers and single-turn potentiometers. Slip-clutches as well as mechanical and electrical limit stops are often conveniently located in a separate gearing subassembly. Often all that is required are idler gears for coupling the parallel shafts of any array of rotating devices. In summary, where particularly severe gearing specifications must be met, it is often simplest to provide most of the required reduction ratio in the gearhead, and to provide a last stage or two of special gearing to meet the required specifications.

Many construction variations occur in practice to meet specific installa ion requirements, or to substitute for older models, designed before standardization came to the gearhead industry. Special mountings are common. Occasionally found is an offset shaft construction where the output gear meshes with an external gear train and the mesh train is adjustable merely by rotating the whole motor-gearhead assembly. • • •

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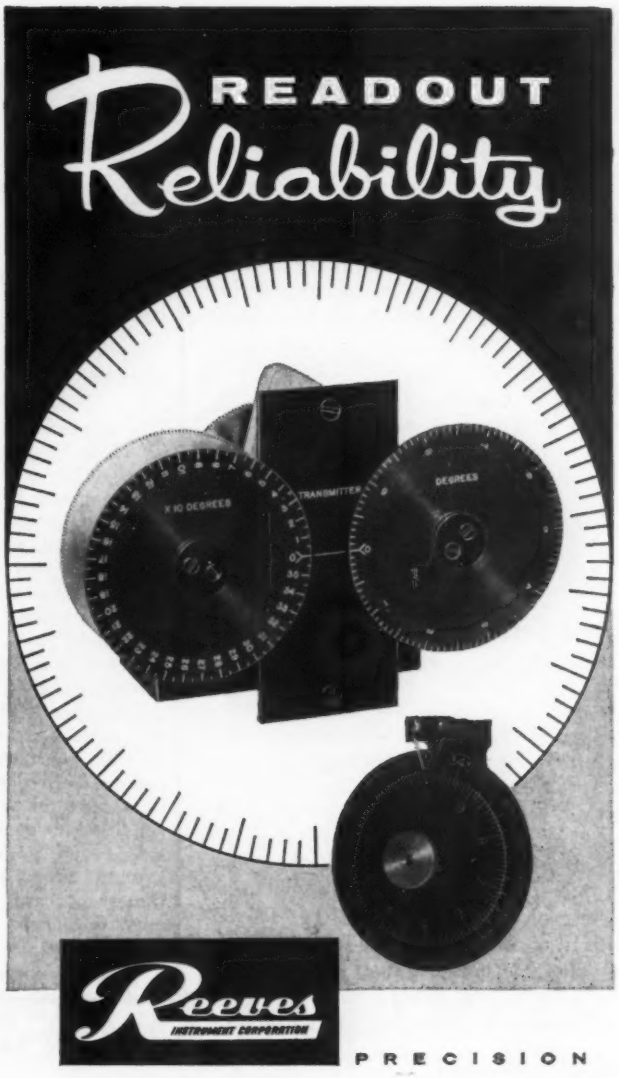

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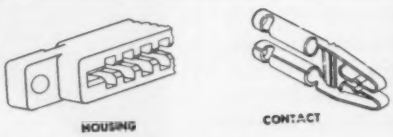

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Tiny Toggle Switch

A toggle switch, 0.78″ x 0.656″ x 1.356″, is believed to be the smallest 3-position switch available. Keying tab measures 0.025″ thick. Flexible insulation shields the terminals. Electrical rating: 5.0 amps at 120/240 volts ac; 3 amps at 30 volts dc inductive at sea level; and 4 amps at 30 volts dc resistive at sea level. Other ratings available. Milli-Switch Corp., Gladwyne, Pa.

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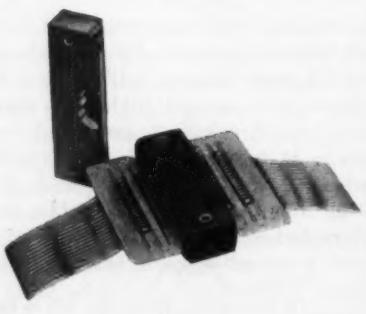

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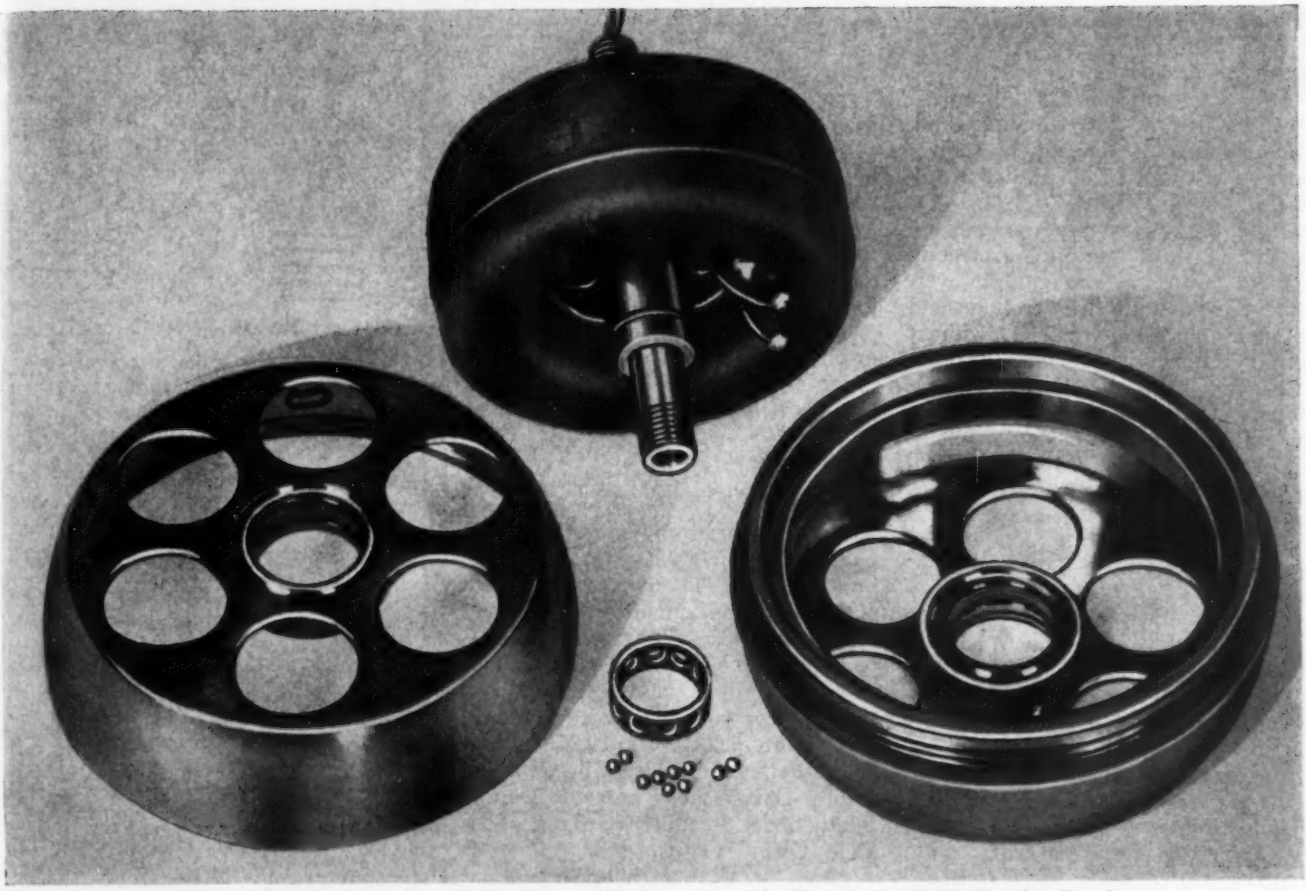

Gyro spin motor shown partially disassembled, produced by Fafnir for B-58 Hustler Bombers

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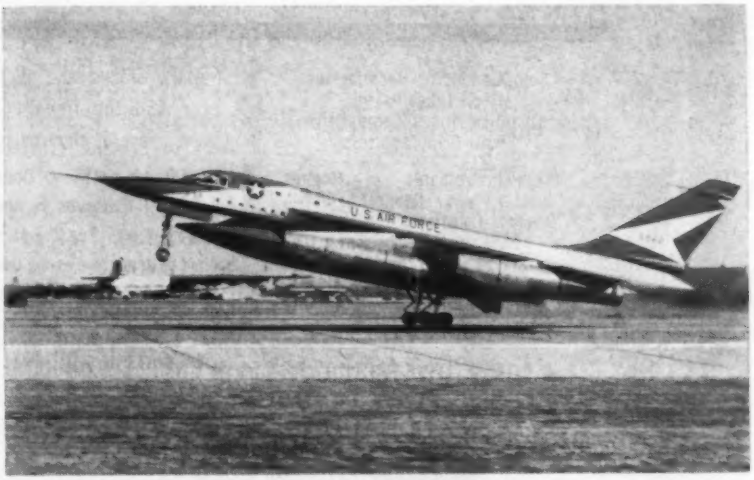

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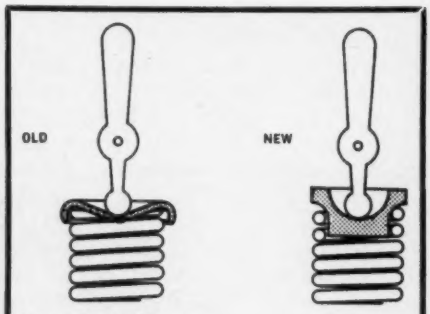

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PI-523

Technical Wire Products, Inc.
48 Brown Avenue, Springfield, N. J.
Please send me Fuzz Button samples and literature.

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COMPANY .....

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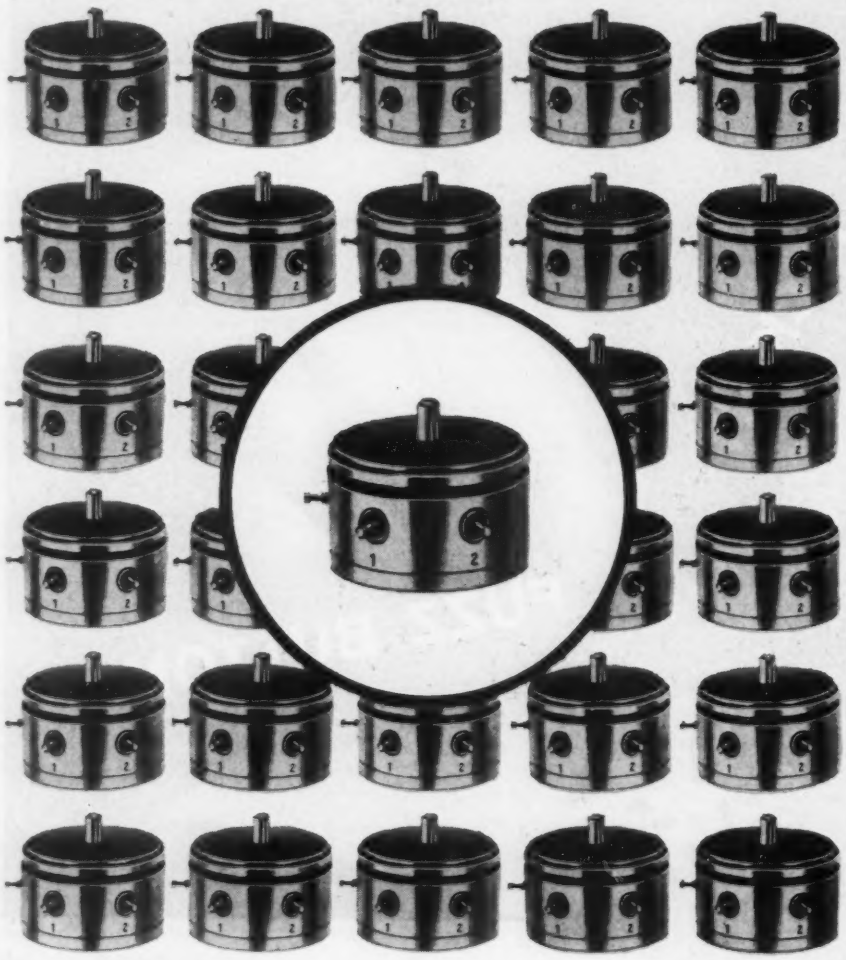
CIRCLE NO. 59 ON INQUIRY CARD



NOW . . .

Metal Film Potentiometers

Here is a new addition to MECHATROL'S product line of precision rotating components . . . . . METAL FILM POTENTIOMETERS.

Using a unique new process, MECHATROL manufactures the deposited film potentiometer resistance element in a high vacuum chamber using electron bombardment techniques. This provides a thin film metallic resistance element of extremely fine granularity capable of being resolved into infinitely small changes in resistance. Resolution is better than 0.01%.

MECHATROL'S thin film potentiometer exhibits superior wear and rotational life under conditions of high ambient temperature and severe vibration and shock. Standard units measure 1-1/16 inches in diameter and are available for servo or panel mounted applications. Special units designed and manufactured to meet your exact specification.

FEATURES:

Resolution . . Better than .005%
Temperature . —55°C to +125°C
Vibration . . . 10 g's, 10-2000 cps.
Rotational Life . . 2,000,000 cycles @ 40 RPM

Write for full details.

SM/I SERVOMECHANISMS/INC.

MECHATROL DIVISION

1200 Prospect Avenue, Westbury, New York

MECHATROL OF CALIFORNIA, 200 North Aviation Blvd., El Segundo, California

CIRCLE NO. 19 ON INQUIRY CARD

NEW COMPONENTS

Tiny Strain Gage Transducer

"Smaller than a dime" strain gage transducers weigh 0.5 gms and measure 0.050" thick. These flush-diaphragm absolute pressure transducers featuring high frequency response are available in ranges 0-10 psi to 0-100 psi, in absolute, gage or differential. Excitation: 15 volts. Output: 5 millivolts, full scale open circuit. Combined error due to non-linearity and hysteresis: less than ±1.0% of full scale. Ambient temp. limits: −65 to +150F. Statham Instruments, Inc., Los Angeles, Calif.

Write No. 446 in Box on Inquiry Card

Non-Polar Capacitors

Developed for ac circuits but serving under certain conditions in dc circuits, solid tantalum capacitors have been made non-polar by connecting back-to-back two capacitors of identical value. Capacitance values range from 0.16 to 160 μf; working voltages: 6, 10, 15, 30, 35 and 50 v for continuous operation at 85°C to 105°C if derated 85%. Kemet Co., Cleveland, Ohio

Write No. 480 in Box on Inquiry Card

System Simulator

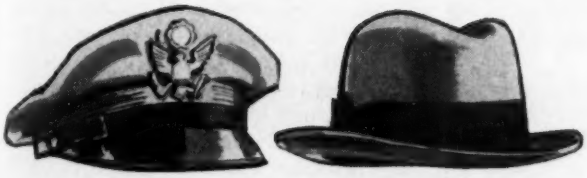
Unit simulates a wide range of systems described by linear second-order differential equations. It is suitable for real time and repetitive scales and has a wide choice of component values of 1 percent accuracy. Assembly consists of: 6 amplifiers, 8 interconnecting units of three basic types, a square wave unit and a stabilized dc power supply. It is particularly intended as an inexpensive instrument for use in teaching the basic principles of analogue and simulator techniques, but has also many uses in industrial research and development laboratories. Feedback Ltd., Crowborough, Sussex, England.

Write No. 322 in Box on Inquiry Card

Micro-Miniature Capacitors

Said to be the smallest capacitor commercially available, ceramic capacitors have a maximum size of 0.1" sq. by 0.05" thick, with a rating of 30 wvdc. Capacitance values range from 10 to 220 μμf., with a maximum capacitance change of ±10% over the temperature range −55 to +85C. Meeting the requirements of MIL-C-11015B, the capacitors are used in miniature computers, transceivers and modular packages. Gulton Industries, Inc., Metuchen, N.J.

Write No. 312 in Box on Inquiry Card



FOR MILITARY & COMMERCIAL SYSTEMS...

COMPONENTS FROM EAD

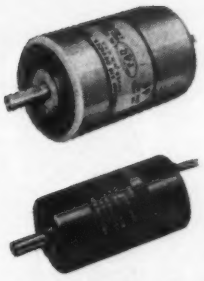
where rotation has been a science for 20 years!

At EAD, rotation has been a science since the early days of electronics . . . 20 years ago . . . when EAD first specialized in the design and production of miniaturized rotating electrical equipment.

For the designer of military or commercial systems, this experience combined with EAD's single-minded insistence on constant product improvement, means a line of standards and specials to meet the most critical of today's demands.

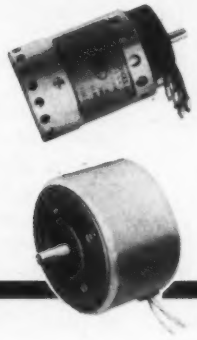
EASTERN AIR DEVICES, Inc.
A DIVISION OF NORBUTE CORPORATION
353 Central Ave., Dover, New Hamsphire

Send us your specifications. Let us submit our proposal without obligation...Our service is as reliable as our products!



MOTORS

Fractional, sub-fractional. Induction and hysteresis types with associated gear reductions. Available in 50, 60, 400 cycles, single, dual and variable frequency, dual voltage. Single-, two-, three-phase operation. Horsepower from 1/3500 to ½. Dia. from 1" to 6⅝".

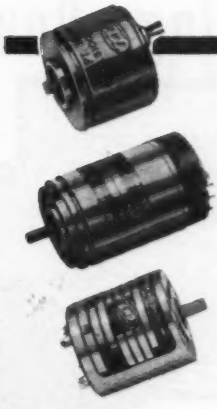


ALTERNATORS

From 1" to 6⅝" diameters. Power to 1000 VA. Wide frequency range. Low harmonic content. Sine waves with maximum 2% total distortion. Single-, dual- (sine-cosine), three-phase. Dual frequency units, for special applications, produce a combination of frequencies.

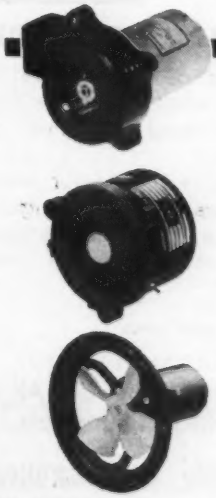
SERVO MOTOR GENERATORS

Avail. in Sizes 8, 10, 11, 15 & 18. Damping servo motor generators (tachometers) and temperature compensated, integrating tachometers — supplied as tachometers only or with integral servo drive motor. Special voltages, scale factors and different compensation characteristics can be provided.



SERVO MOTORS & INERTIALLY DAMPED SERVO MOTORS

The basic actuating devices in AC automatic control systems. Provide dynamic response, reliability in extreme environments and high efficiency. Supplied with leads or terminals, with special voltage and power ratings and with precision gear heads for any reduction ratio. Sizes 8, 10, 11, 15 & 18.



BLOWERS & FANS

Light weight centrifugal blowers, ring mounted fans and vane axial fans. Capac. to 1000 cfm. Special designs available for high static pressures. Single, double ended, 50, 60, 400 cycles, special frequencies and variable frequency (50-450 cycles, 360-1600 cycles, etc.).

CIRCLE NO. 62 ON INQUIRY CARD

NEW COMPONENTS

Metallic Static Seals

Seals guarantee zero leakage from a vacuum to greater than 30,000 psi at temperatures from —32F to +2200F. They may be reused 10 to 15 times and still maintain zero leakage capabilities. Any shape seal from ⅛" O.D. to 3 ft and up can be supplied. They have been used in hydraulic, cryogenic, fuel, and hot gas applications. Servotronics, Inc., Buffalo, N. Y.

Write No. 490 in Box on Inquiry Card

Voltage Reference Elements

Hermetically sealed, silicon Zener reference elements for military and industrial power supplies provide voltage stability of ±1% or better over the temperature range from —55°C to +100°C. The silicon diodes' 6.2 operating voltage makes them suitable for precision instrumentation, computer and other data processing equipment. The diodes used in series obtains higher voltage reference levels. International Rectifier Corp., El Segundo, Calif.

Write No. 359 in Box on Inquiry Card

DC Power Supply

Using a stable reference, high-gain differential amplifier and series regulator, a power supply holds output voltages to 1 mv under all load conditions and over its entire voltage range of 0 to 50v dc. Line regulation: ±0.002%; load regulation: 1 mv; ripple: less than 1 mv; weight: 3 lb. 6 ozs; input: 105-125 v ac. Valor Instruments, Inc., Gardena, Calif.

Write No. 425 in Box on Inquiry Card

Relay Accessory

The Clinchmo, an inexpensive, two piece plastic device straightens and stiffens leads of microminiature relays. The long leads used in printed circuits normally tend to break off at the seal; the closely spaced wires also snarl. Clinchmo eliminates these problems by means of a tapered and grooved piece of plastic, the thin end of which butts against the relay header; when the rectangular plastic collar is pulled toward the thick end, all leads fall into the grooves providing a rigid assembly. The device, which is furnished with all of the company's long lead microminiature relays, is available as a sample upon request. Filtors Inc., Port Washington, N. Y.

Write No. 367 in Box on Inquiry Card

Digital Modules

Said to provide two to four times the circuit density of previously available units, new 200 kc digital modules are contained on 4" by 4" glass based printed circuit cards incorporating a 35-pin connector. Four identical but independent flip-flop circuits are provided on one model. Each flip-flop includes set and reset diodes plus AND gates for use as a binary counter or shift register. Other circuit configurations include gate drivers; diode gates; input gates; Nixie drivers; and transistor drivers. Packard Bell Computer Corp., Los Angeles, Calif.

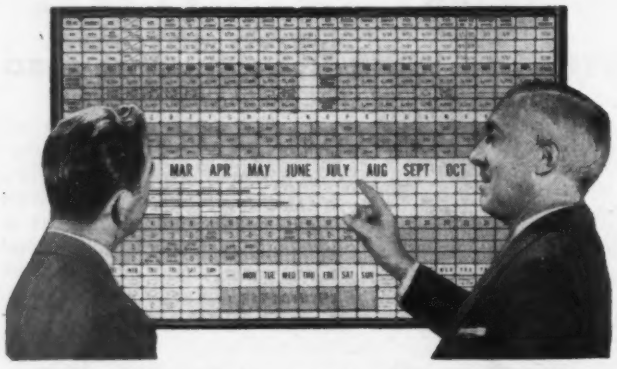
Write No. 452 in Box on Inquiry Card

High Current SCR

Forward current rating for 8 models of silicon controlled retifiers averages up to 70 amps ac and 110 amps dc. Their peak reverse voltage ratings range from 25 to 400 v. Typical gate current required to fire units is 15 ma at 1.5 v; max gate voltage required to fire is 3.0 v. Turn-on time varies from 1.0 to 4.5 μ sec, turn-off time from 15 to 25 μ sec. Hard-solder construction provides a high degree of protection from thermal fatigue. General Electric Co., Liverpool, N. Y.

Write No. 507 in Box on Inquiry Card

How To Get Things Done



BOARDMASTER VISUAL CONTROL

Gives you a Graphic Picture of your operations, spot-lighted in color. You See what is happening at a glance. Facts at eye level — saves you time, prevents errors.

Simple, flexible — easily adapted to your needs. Easy to operate. Type or write on interchangeable cards, snap in grooves. Ideal for production, scheduling, sales, traffic, inventory, etc. Made of metal. Compact, attractive.

Full price $49.50 with cards

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24-Page Illustrated Booklet AK-50 Mailed Without Obligation

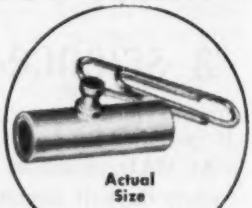
GRAPHIC SYSTEMS, Yanceyville, North Carolina

CIRCLE NO. 64 ON INQUIRY CARD

not just SMALL

this is THE SMALLEST

INERTIA SWITCH



new millimite

- only ¾" long x ¼" diameter
- weighs less than 1/5th of an ounce!

Light, tiny and simple, the new MILLIMITE has no springs, no bearings to wear or vary with time and temperature.

High, long-term accuracy. Meets MIL-E-5272 environmental spec.

Used for:
- Centrifugal and straight-line acceleration applications
- Shock and Vibration indication (circuit control)
- Initiating fuzes

MILLIMITE SPECIFICATIONS:
General: SPST, unidirectional, normally open
G Range: to 250 G's. Factory calibrated and sealed at any point
Accuracy: ± 10% (closer tolerances on request)
Damping: Undamped
Reset: Automatically resets when acceleration is removed
Electrical Rating: 1 amp @ 28V DC
Terminals: 1 pos. and 1 case ground
Temperature Range: — 65° to + 250° F.

Write, wire, phone for descriptive brochure EMD 4-61.

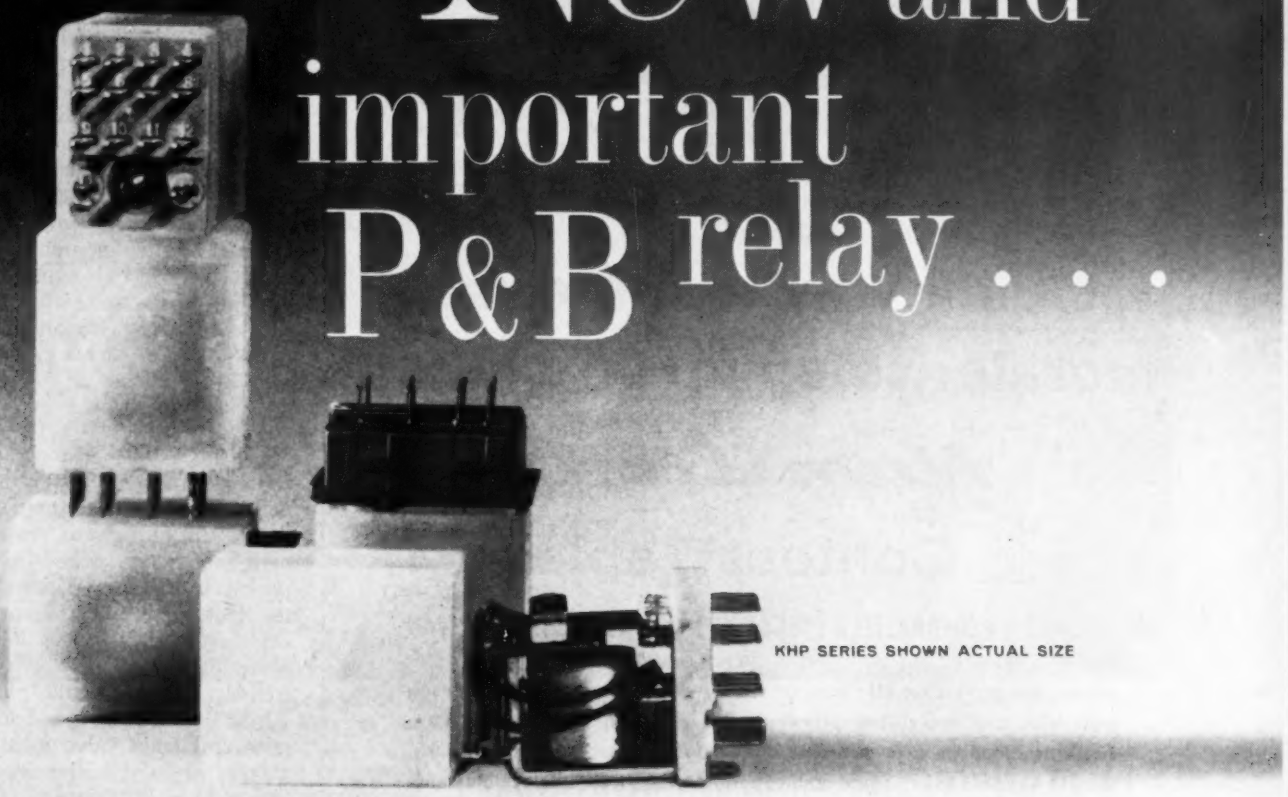
INERTIA SWITCH Inc.

311 West 43rd St., New York 36 • JUdson 6-5880

CIRCLE NO. 63 ON INQUIRY CARD

CIRCLE NO. 65 ON INQUIRY CARD →

a New and important P&B relay . . .

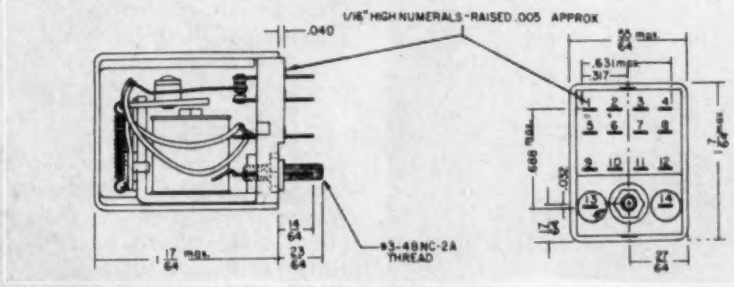


KHP SERIES SHOWN ACTUAL SIZE

having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES SPECIFICATIONS

CONTACTS:
Arrangement: 4 Form C, 2 Form Z.

Material: 1/32" dia. Silver standard. Silver cadmium oxide and gold alloy available.

Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:
Resistance: 11,000 ohms max.

Temperature: Operating Ambient: —45°C. to +70°C.

Power: 0.5 watts min operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.

DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.

MECH. LIFE: In excess of 100 million cycles.

SOCKET: Solder lug or printed circuit terminals. Available as accessory.

DUST COVER: Standard.

TERMINALS: Solder lug and taper tab.

KHP SERIES RELAY NOW AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

Quick way to increase morale...step up efficiency

Hamilton

"L" Contour Tables

PROVIDE A PERSONALIZED EXECUTIVE WORK AREA FOR EACH MAN

Make it easy for your top men to do their best work—every day. High morale and productive efficiency go hand in hand when you provide each man with the **individual privacy** of a Hamilton L-CONTOUR TABLE. **Individualized private cubicles** offer modular, space-saving flexibility. **Single support** keeps board stable, perfectly balanced, readily adjustable from horizontal to vertical. **Generous storage** includes reference drawer, tool drawer, catalog drawer. **Glare-free** linoleum reference surface and a host of other features make the Hamilton L-CONTOUR TABLE a real investment in stepped-up productivity. **Write today** for full details.

Hamilton
PROFESSIONAL AND SCIENTIFIC FURNITURE
Hamilton Manufacturing Company, Two Rivers, Wisconsin
new dimensions in time and space efficiency for: physicians; dentists; industrial, hospital, school laboratories; draftsmen; printers; libraries; home laundries.

CIRCLE NO. 66 ON INQUIRY CARD

NEW COMPONENTS

Self-Locking Capscrews

Specifically designed for use in environments where vibration, high tensile strength, corrosion and high temperatures exist, self locking capscrews consist of: a conventional hex head capscrew with a double cap; a concave head, and a seating-type, all metal, reusable locking collar. They are claimed to have greater tensile strength than conventional capscrews and an elasticity three times as great. Klincher Kapscrew, Inc., Indianapolis, Ind.

Write No. 370 in Box on Inquiry Card

Air Valves

Rated at 150 psi, 3 way and 4 way air valves operate at 1000 cpm, continuous duty. Cycling speeds as high as 2100 cpm have been reached for intermittent periods of 20 min. The valves are said to feature design innovations that lengthen coil life and improve valve performance through use of an extremely short solenoid plunger stroke (3/32") and to reduce friction in both pilot and main valve members. Available in ¼ to ¾" pipe sizes. Barksdale Valves, Los Angeles, Calif.

Write No. 360 in Box on Inquiry Card

Direct Counting Instrument

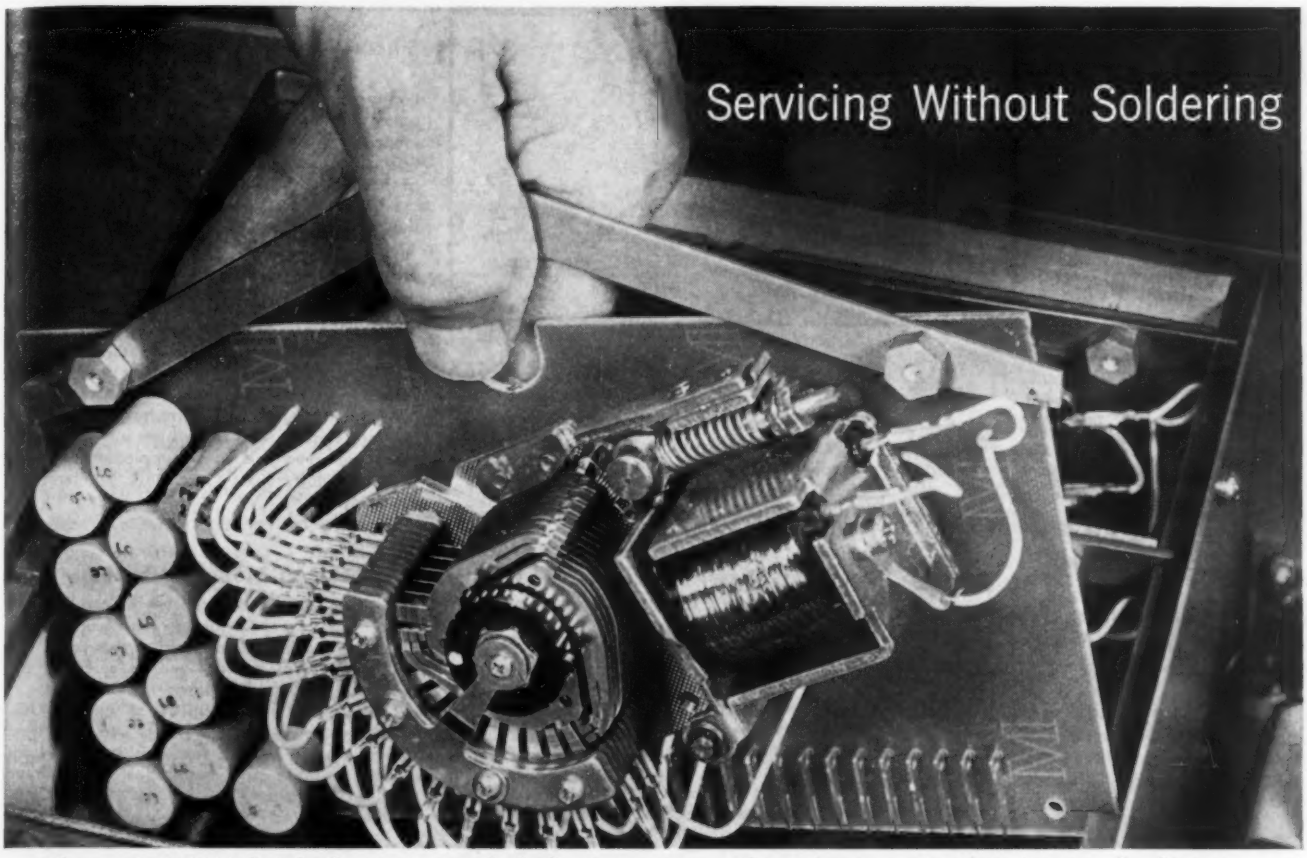
A 100 Mc transistorized gated counter serves as a triple purpose instrument for counting, time interval, and frequency measurements. Using a new logic, one model counts random events with better than 10 nanosecond double pulse resolution and functions as a time interval meter to measure duration to within 10 nanoseconds. It offers nine digits of storage with in-line (Nixie) display. As a counter, it may be started or stopped locally or remotely with a built-in fast electronic gate. Eldorado Electronics, Berkeley, Calif.

Write No. 358 in Box on Inquiry Card

Servo Clamps

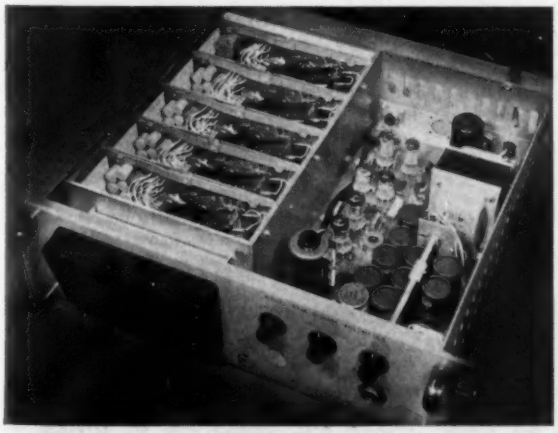
Standard mounting hardware for synchros, servomotors and pots, machined from solid aluminum stock, provide greater strength under shock and vibration than conventional powdered metal and stamped construction. Two clamp sizes for use on six different housing sizes facilitate inventory handling. Theta Instrument Corp., Saddle Brook, N. J.

Write No. 423 in Box on Inquiry Card



The new NLS 481A digital voltmeter features both plug-in stepping switches and a snap-out readout that virtually eliminate use of a solder gun or other tools in servicing. Note the "finger-control" leverage bars for easy switch removal.

Applications include production testing, instrument calibration, laboratory testing, receiving inspection.



The 481A features the basic circuitry of the NLS 481, today's most widely used digital voltmeter.

Announcing the NLS Low-Cost 481A Digital Voltmeter

Here is the time-proved 481 with new features to permit replacement of all stepping switches and decade resistors in minutes instead of days. Plug-in stepping switch assemblies in the 481A also allow troubleshooting by the substitution method. Like the thousands of 481s in use, the new 481A features ±0.01% accuracy and completely automatic operation at low cost. It measures DC voltage from ±0.001 to ±999.9; AC or low-level DC with plug-in accessories. Input impedance is 10 megs . . . balancing time is 1 second, average . . . internal standard cell verifies calibration.

Although the 481A features exclusive plug-in stepping switches previously found only on higher cost NLS digital voltmeters, it sells for only $1,525, complete. Delivery is from stock – 15 days if stocks are temporarily depleted. NLS will continue to manufacture the 481 in volume for customers who have standardized on this instrument or where initial price is more important than the long-term savings in servicing offered by the 481A.

A statement of policy: The 481 A is not a "pie-in-the-sky" instrument or prototype. It has long since undergone complete testing and is now in volume production to assure you prompt delivery of a fully-tested, quality instrument.

Call your NLS regional office or sales representatives for a demonstration of the 481A, 481 or any digital measuring instrument. If you prefer, please contact NLS for additional information.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

CIRCLE NO. 67 ON INQUIRY CARD

For Your Literature File

NEW CATALOGS

Most of these catalogs contain complete specs, mounting configurations and other important details associated with the application of the products described. For your free copy of the catalogs listed on this page, enter the appropriate number of the item on the Inquiry Card.

Military Terminal Boards 667

A complete line of military terminal boards are described in a catalog which includes a quick-selection table, drawings with important dimensional information, and details on available hardware and accessories. (8pp) Kulka Electric Corp., Mt. Vernon, N. Y.

Machine Tool Control Transformers 668

Important suggestions for determining proper transformers are included in a catalog that concisely describes functions of machine tool control transformers. It contains individual regulation curves for nine standard rating transformers; curves indicate percent of overload at 20% and 100% power factor that each transformer accommodates and also indicates volt-amp inrush at 90% secondary voltage. Used as a guide, the suggestions can avoid using over-rated or under-rated transformers. (4pp) Acme Electric Corp., Cuba, N.Y.

Hi Frequency Calibration 970

A paper discusses the techniques and errors involved in applying devices such as A-T voltmeters, thermal voltage converters and micropotentiometers to typical problems arising in the calibration of electronic voltmeters. Sources of error discussed include human error, loading effects, voltage drop in connecting leads, stray field pickup, effect of ground currents of signal and power frequencies, transmission-line effects, and response and waveform error. (8 pp) Ballantine Labs., Boonton, N. J.

Circuit Testing 967

Covering a company line of test equipment, brochure contains typical case histories illustrating the equipment's uses, advantages and savings in production line checkout and operational testing of aircraft voltage regulators, missile electronic assemblies, aircraft assemblies, diode matrix systems, printed circuits, missile launching control, maintenance inspection, aircraft components, and airborne military equipment. (12 pp) Lavoie Labs., Inc., Morganville, N. J.

Precision Gears 991

Precision worms and gears are said to offer designers of small-package assemblies extreme accuracy, positive backlash control, great shock strength and low noise level in all high ratio, right angle gearing applications. Catalog includes detailed drawings. (24 pp) PIC Design Corp., East Rockaway, N. Y.

Electromechanical Chopper 966

Miniature SPDT, hermetically sealed chopper owes its versatility to a non-resonant design. It consists of two mechanically independent parts, the coil and switching assembly. Bulletin describes these non-resonant switches and their operation and gives test circuits with tabulated terminology. (7 pp) The Bristol Co., Waterbury, Conn.

Rotating Equipment and Accessories 969

Condensed reference guide covers ratings and other essential technical data on variable transformers, automatic voltage regulators, electrical connectors, synchronous motors, packaged transformer primaries, decade line correctors, loading reactors and adjustable ac/dc power supplies. (10 pp) The Superior Electric Co., Bristol, Conn.

Coated Glass Fabrics 677

Coated glass fabrics combine specially formulated high temperature varnish or resin coatings and inorganic woven glass fabrics with a wide range of electrical and mechanical properties. Brochure gives applications, including hand wound and stick wound transformer coil insulation, heavy duty transformer coil insulation and motor and turn coil insulation. Products described include epoxy and varnish coated glass, standard (NEMA) grade, commercial (I.C.) grade and yellow varnished glass fabrics. (5 pp) Minnesota Mining & Mfg. Co., St. Paul, Minnesota

Hydraulic & Pneumatic Equipment 951

Lap fit valves with 0.00002" clearance; filters with mesh sizes down to 5 microns; and atomizers with flow ranges from 8 to 300 lb per hr are detailed in a catalog describing: hydraulic and pneumatic valves, rotary pressure switches, precision filters, hydraulic cylinders and fuel atomizers. (8 pp) IMC Magnetics Corp., Maywood, Calif.

Multiple Connectors 952

A solderless termination technique for applying contacts directly to wire ends is described along with one-and two-piece multiple connectors for printed circuit boards. Line drawings show each "snap-in" contact: leaf, blade, fork, flag-fork, and taper-in. Cutaway drawings illustrate connector housings available. Other products described include: component tips, single circuit edge connectors and printed circuit pins. (6 pp) AMP Inc., Harrisburg, Pa.

Silicon Rectifiers 987

Ratings and specifications cover over 400 top hat, stud, insulated stud, plug-in tube replacements and special purpose silicon rectifiers. Special arrangement of data facilitates selection of products. Also included are application and design notes and circuit design constants. (4 pp) Semicon, Inc., Bedford, Mass.

Industrial Heating 679

Electric heater bands, air heating elements, blower-type heaters, immersion units, engine heaters, mineral insulated heating cable, special radiant heaters for process and comfort heating, controls and other elements and equipment are described in a supplement to company's catalog. (22 pp) Edwin L. Weigand Co., Pittsburgh, Pa.

Shaft Flange Mounted Drives 681

Drive units cover a torque range up to 44,000 lb-in. Catalog contains design and construction advantages as well as selection and dimensional data, engineering drawings, accessories, and typical application photos. Also explained are motor mounts for use with these drives; the pre-drilled, steel weldments accommodate rerated foot-mounted NEMA motors (½ to 30 hp). (36 pp) The Falk Corp., Milwaukee, Wisc.

Readout Fact Finder 685

Brochure compares major types of in-line readouts, including electroluminescent, projected image, shpericular optic, Nixie tube, edge lighted and electro mechanical displays. All factors important in selecting display devices are discussed such as readability, life, size, weight, drive requirements, cost and power. (16 pp) Burroughs Corp., Plainfield, N. J.

General Purpose Relays 683

Compact, 25-amp relays are shown in a variety of standard mounting arrangements, with several optional types of terminals and eight different SP and DP contact combinations. Accessories and typical applications are also included. (8 pp). The Hart Mfg. Co., Hartford, Conn.

Instrument Tubes 684

Characteristics and uses for vacuum tubes manufactured specifically for instruments fill a long needed requirement for receiving tubes with tight, stable characteristics and long life. They incorporate advanced military features, except for unnecessary costly shock and vibration controls. Brochure includes description of frame grid tubes and secondary emission tubes. (8 pp) CBS Electronics, Danvers, Mass.

Self-Locking Bolts 686

Bulletin contains design characteristics of self-locking bolts and screws, a table of torque testing per Mil-F-18240 and temperature and strength data. Shown also are physical test data and typical applications. (4 pp) Long-Lok Corp., Santa Monica, Calif.

CONTRACTS

Are you financially stable? You may have to argue the point with a computer, someday. With the use of ferrite memory cores, scientists at Lockheed Electronics foresee the future possibility of a computer for bank use that automatically tells the credit rating and amount of credit the bank can extend. In this type of computer, each memory core would deduce and store just one bit of information about a customer – whether he's been turned down before on credit or whether he is financially stable, for example. When called upon, a memory core would answer "yes" or "no" to the question: "On the basis of what you know, should this person's credit be extended?" (Maybe someday you'll enter Ye Olde Friendly Finance Co. and discuss your financial problems with a machine. Let's hope they build computers with a lot of heart!) Lockheed will produce millions of donut-shaped brain cells, each so small that an eyelash could scarcely be threaded through its center, at its Los Angeles facility. These ferrite memory cores are from 0.030 to 0.080 of an inch in diameter – no larger than a (.). Hundreds to thousands of these are wired into a computer system's memory. Each is required to remember one answer out of a possible two and feed that answer upon request. As simple as this one bit of information may be, when several thousand pieces are stored inside a computer there arises a memory system as complex and with as much capacity (and perhaps more) as the human brain. Units yield information at the rate of 250,000 to 500,000 bits per second depending on the complexity of the machine. The cores, like the computers into which they are wired, are used for an infinite number of jobs. Lockheed Electronics' most recent contract is for the production of over one million cores for National Cash Register Co. of Hawthorne, California.

BRIEFLY:

Sparrow III missile system: $28,177,129 to Raytheon Co., Lowell, Mass. from the Navy.

Slip ring assemblies: $280,000 to Electro-Tec Corp., South Hackensack, N. J. from Avco Mfg. Corp.

Automatic pressure generators: $115,000 to Giannini Controls Corp., Duarte, Calif. from Grumman Airc. Engrg. Corp. for the Navy's Hawkeye test system.

Electronic voltmeters: $180,000 to Orion Electronic Corp. from the Army Signal Supply Agency.

Aircraft equipment: $18 million to Garrett Corp., Los Angeles, Calif., for environmental equipment and central air data systems for the Lockheed F-104 Starfighter.

Electronic defense systems: $9 million to Sylvania Electric Prods., Buffalo, N. Y. from Convair Div. of General Dynamics Corp. for Air Force's B-58 Hustler bombers.

Data processing equipment: $3,590,177 to Burroughs Corp., Detroit, Mich. from USAF for the Sage program.

Flight controls: $600,000 to Texas Instruments, Inc., from Minneapolis Honeywell for the Titan and Scout.

Correlation techniques: $137,431 to Bissett-Berman Corp., Los Angeles, Calif. from Air R & D Command for studies and investigations of correlation techniques for data processing applications.

Decoy discrimination: $325,000 to Avco, Everett, Mass. from Bell Tel Labs. for theoretical and experimental study of decoy discrimination for the NikeZeus system.

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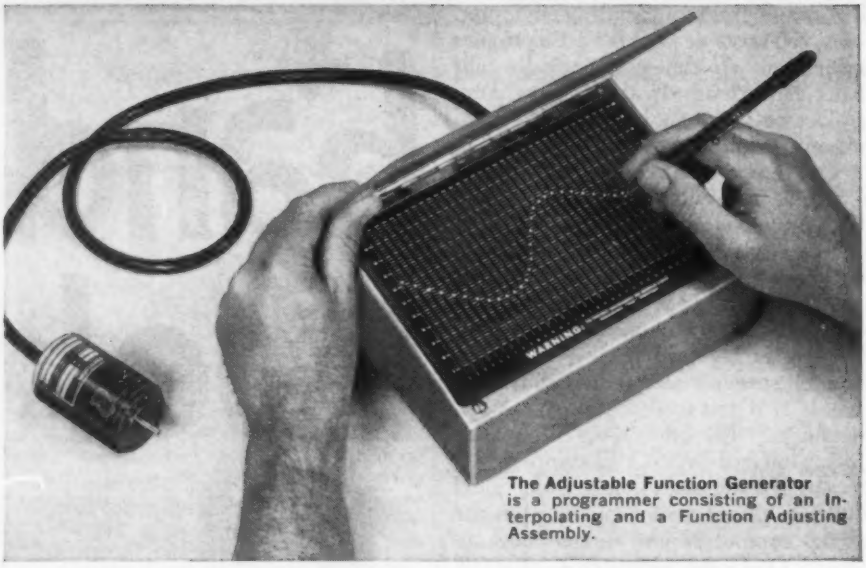

The Adjustable Function Generator is a programmer consisting of an Interpolating and a Function Adjusting Assembly.

FOR A NON-LINEAR SIGNAL OUTPUT—THE VERNISTAT ADJUSTABLE FUNCTION GENERATOR

See that curve on the panel? You adjust it by hand . . . any shape, real quick! You draw your own Y = f (X) curve and pull out a repeating, nonlinear voltage to control the process you require.

Almost any process that can be controlled by a varying voltage can be controlled by the signal from a Vernistat Adjustable Function Generator.

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In the Vernistat, the autotransformer uses equally spaced taps, giving a highly linear output. These taps can be crowded or spread apart, in which case you get a permanent, nonlinear output related to their spacing. In the Function Generator, the autotransformer has 101 equally spaced taps which **you can select** to form the nonlinear function you desire. Using 34 sliders, you set your voltage up and down the Y-axis, graphing the Y-values against X. The X-axis represents angular position of the shaft over a range of 10 shaft turns.

Actually, the entire Function Adjustable Assembly is nothing more than a switch for pulling the proper curve out of the Vernistat. Once the curve is set an Interpolating Vernistat provides for a smooth voltage output between taps. The steel case of the Assembly is 3 x 7 x 8 inches, which shows you how compact the mechanism is.

APPLICATIONS

You can use the Function Generator both as a lab instrument and a system component. Some important uses are:

1. Rapid Empirical Determination of Functions: Eliminates time-consuming mathematical calculations and the production and wiring of a large number of special padding resistors. Once a curve is determined, a nonlinear Vernistat can easily be constructed to provide a simplified, permanent, function-generating unit.

2. Linearization: The Function Generator can be used to compensate for nonlinearities in electronic systems. It can be placed in series with the signal to be corrected or used as a nonlinear feedback element in a servo loop.

3. Input to Analog Computer: It converts nonlinear data to an electrical input.

4. Control and Programming: Used in chemical, petrochemical and other continuous processes to control a variety of functions. If the shaft is rotated at constant speed, control will be a function of time.

Several series of Vernistats are available for use with the Function Generator. For a complete description drop us a line.

DOES THE BURDEN CHANGE THE NATURE OF THE BEAST?

The subject is LOADING ERROR. Consider, for example, the Vernistat a.c. potentiometer—a highly linear device, which . . . be the load heavy or light . . . retains high efficiency. This is a direct result of its low output impedance which brings unique benefits to forward-looking designers:

1. **Loading error is extremely low.** For instance, the loading error on a Model 2B3 Vernistat operating into a 500K load is .026% or less. A d.c. potentiometer with the same input impedance (65K) and the same load has a maximum loading error of about 2%. Our Model 3B with a Z_{in} of 50K and Z_{out} of 40 ohms takes the loading error down to .008%.

2. Several loads can be driven from a single Vernistat without excessive loading error. (And Vernistats can drive other Vernistats in cascade.)

3. Stray pickup from electrostatic fields is cut to practically nil.

4. Phase shift due to stray capacitance is greatly reduced.

Where the specs call for high resolution plus high accuracy, the high resolution pots are thoroughly baffled. To attain high resolution, the wirewound pot requires many turns of fine wire with a resultant increase in output impedance, loading error and quadrature. Thus, accuracy goes to pot. With Vernistat both specs are attainable.

When specifying accuracies many designers tend to separate linearity and loading error requirements. Why not think in terms of **loaded linearity;** that is, linearity **plus** loading error? That's the way to tie down total error at once. If you can afford to be a happy-go-lucky on this point, you may end up with isolation amplifiers supporting very accurate pots in your electronic system—where a single Vernistat could do the job better and perhaps more cheaply.

The finer details have been written up on 6 coarse sheets of paper headed: "Loading Error—A Review." If you deal with data transmission in analog equipment (for Doppler radars, navigation systems, fire control computers, etc.)—you'll be more than diverted. Write for your copy today.

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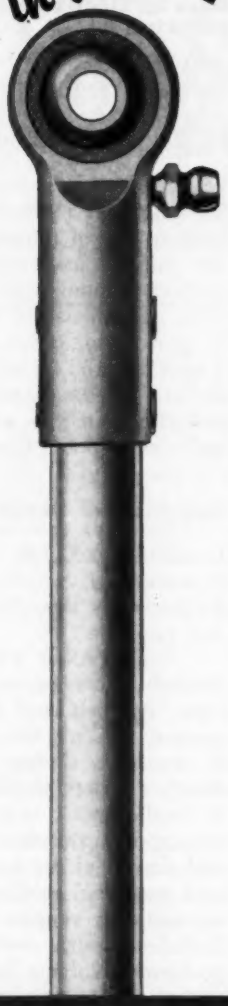

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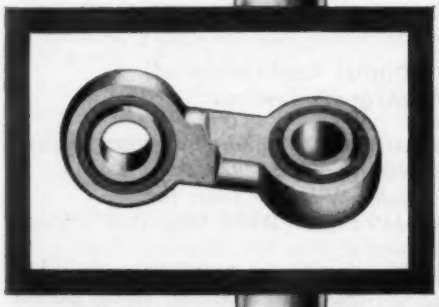

The single ball construction of the Unibal Spherical Bearing permits its comparatively simple adaptation to special applications such as this double offset link.

Heim Unibal Rod Ends as used in the linkage for the dampener installation on the Atlas fuel manifold.

Heim Unibal Spherical Bearing assembled with the variable pitch stator vanes in the jet engine, act as the pivot points.

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BOOK REVIEWS

Uses of Electricity in the Oil Industry

E. A. Reeves
296 pages, $10.00
John DeGraff, Inc.
31 E. 10 St., New York 3, N.Y.

While primarily designed as a reference for engineers in the oil industry, this book is also of interest to engineers in the mining and chemical industries. Sections dealing with equipment of a more general nature will be of interest to power engineers in any industry. Topics covered include control systems, electric motors, telecommunications, cathodic protection and other electrical and electronic equipment.

Analysis and Design of Mechanisms

Deane Lent, M.I.T.
Prentice-Hall, Inc.
Englewood Cliffs, N. J.
328 pages, $9.35

Written expressly as an introductory text, "Analysis and Design of Mechanisms" presents the "how" and "why" of machine design. It simply and clearly develops the basic fundamentals of displacement, velocity and acceleration, applying them to both the analysis and design of mechanisms. The book uses graphical methods wherever they are faster or simpler than calculations. Includes design methods in realistic problems involving linkages, cams, gear trains and epicyclic trains.

Digital Applications of Magnetic Devices

Albert J. Meyerhoff, Senior Editor
604 pages, $14.00
John Wiley & Sons, Inc.
440 Fourth Ave., New York 16, N.Y.

This book is an excellent, and probably the only, practical text on digital magnetic devices. Prepared by members of the technical staff of Burroughs Corp. with the original material written by 25 authors associated with 6 engineering organizations, the book provides the necessary theory for the design of the major digital magnetic circuit types, and complete design examples of several specific systems. Computer engineers, with this book, can solve such problems as: the suitability of a magnetic circuit; specific components to be used; design procedures for complete systems; and, in great detail, the particular effects of parameters of magnetic core characteristics and geometry on design and performance.

PRODUCTION AIDS

If you want more information on the production aids discussed below write the appropriate number on the reader service card.

PRODUCTION SOLDERING **899**
of printed circuit panels by an entirely new wave method makes possible standard performance to 0.015 spacing of circuitry. Utilizing a new principle of mixing oil with solder, a new machine eliminates icicling and bridging by reducing oxidation and drossing. In operation, the unit raises a wave in molten solder mixed with oil. This produces tiny droplets of oil throughout the solder wave which reduces oxidation and keeps solder dross-free. Fully automatic, machine has conveyor speeds from 0-72" per minute. Carriers will accommodate virtually any printed circuit panel. Hollis Engineering, Inc., Weston, Mass.

TINY ARC-PLASMA SPRAY GUN **871**
reaches previously inaccessible surfaces. The 2" long, 1½" dia, 1 lb unit is said to be the smallest ever commercially produced. Yet, it achieves a power level of 25 kw. The new gun has successfully sprayed corrosion resistant and high temperature coatings on interior walls of small rocket nozzles, cylinders and chambers. Plasmadyne Corp., Santa Ana, Calif.

AUTOMATE SOLDERING OF COMPONENTS **872**
with a machine that contains variable and changeable adapters to accommodate a variety of components produced in and for the electronics industry. Parts pass through heating chamber and emerge completely soldered. Kester Solder Co., Chicago, Ill.

TRANSISTORIZED VIBRATION INSTUMENTS **873**
for vibration indication and protection, operates within three ranges: 0 to 0.1 mil, 0 to 1.0 mil and 0 to 10 mil. On the most sensitive range, 0 to 100μ inches, the ac operated unit measures vibration amplitudes below 10μ inches and detects changes of only 1 or 2μ inches. Applications include protection of compressors, generators, motors, pumps, automatic handling equipment and production machinery. Indikon Co., Watertown, Mass.

ACCURATELY AND RAPIDLY TEST **874**
NPN and PNP transistors with a new instrument that measures the four basic parameters necessary to check a transistor's performance: Beta, I_{ebo}, I_{co} and I_{eo}. Ideal for incoming inspection and production line testing, the tester requires no special connections and adjustments. Transistors simply plug into unit; test is made by positioning function switch. Results read directly from meter. Magnetic Research Corp., Hawthorne, Calif.

AUTOMATIC TERMINALING MACHINE **875**
handles six wire sizes having any of twelve insulation diameters. Adjustment is accomplished by setting a concentric selector dial. To compensate for variations in stranding, the wire dial sets at intermediate points. Replacement of rolling-tools and anvils is a simple snap out/snap-in action. Ark-Les Switch Corp., Watertown, Mass.

SPIRAL RESISTOR GRINDER **876**
automatically produces carbon and metal film resistors to ±0.15% tolerances. Machine feeds one resistor rod at a time into chucks, lifts away grinding wheel when precise value is reached, discharges the finished product into chute and quickly begins the next cycle. It handles resistors 1/16" to 3/8" in dia, and from 5/16" to 2" long. Production rates depend on number of spirals to be ground. Associated American Winding Machinery, Inc., New York, N. Y.

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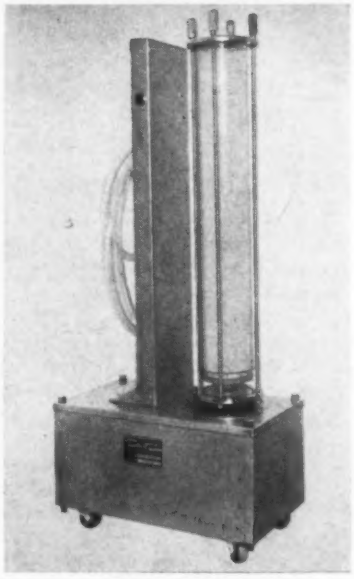

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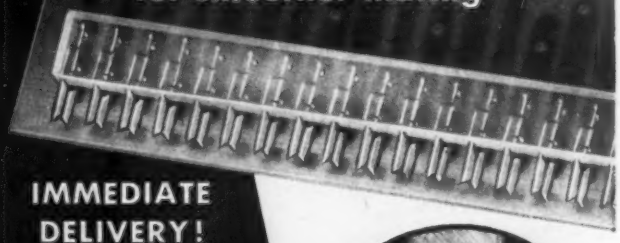
completely interchangeable with available types with FULL RADIUSED CONTACTS for smoother mating



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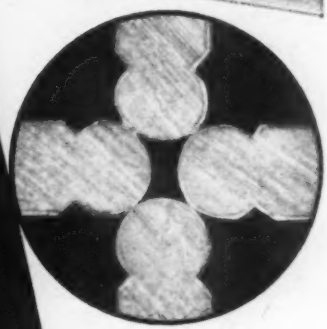

Microphotographic view of Methode Printed Circuit "FORK" CONTACTS

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Take Model 6885 shown at right. Integral vibration isolation between mounting bracket and switch body makes possible exceptional performance under shock and vibration. Its accuracy is ±4% under all conditions, including ambient temperatures ranging from −75°F to 250°F, as well as vibration at all frequencies through 2,000 cps. It weighs only 10 oz., measures $3\frac{3}{8}$" to $4\frac{3}{8}$".

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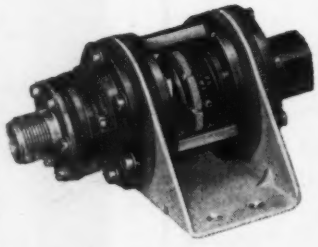

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Model 6885 shown above is one of more than 300 pressure switches available from Consolidated Controls for missile, aircraft and nuclear applications. Working pressures range from 10" of water to 10,000 psi at ambient temperatures from −65°F to 1000°F. Standard models for

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- differential pressures
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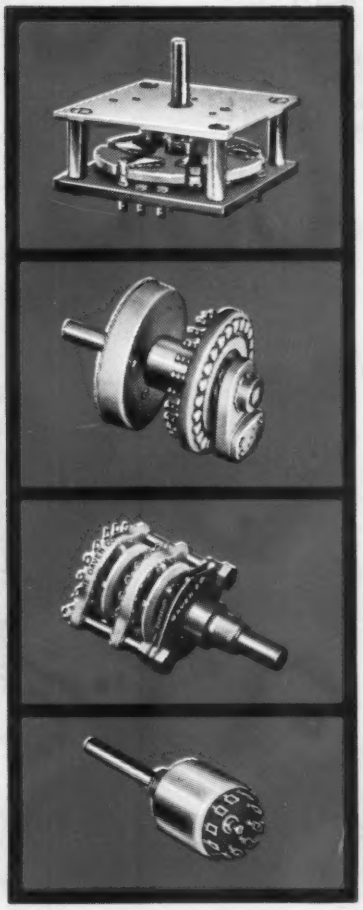

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CIRCLE NO. 76 ON INQUIRY CARD

SERVO PACKAGE PROBLEMS ?

Here's how CPPC is advancing the state of the Servo Art through miniaturization including extensive weight reduction

A TRANSMITTER UNIT →

Within this miniaturized transmitter unit ($1\frac{17}{64}$" square by $2\frac{1}{2}$" long, less connector projection) is a size 8 synchro transmitter driven through a 100π:1 gear train. The input shaft features a detent action which accurately positions the transmitter in 13.7′ increments. There are 48 detents available and the transmitter EZ may be aligned with any detent.

A typical application of this unit is remote control of radar scanning equipment. **Weight: 3½ oz.**

← MINIATURE (2 ELEMENT) SERVO GEAR TRAINS

In the smaller assembly (1" wide by 1.812" long) any gear ratio up to 1000:1 can be supplied. In the other assembly (1.281" wide by 1.859" long) gear ratios up to 4000:1 are available. Choice of size 8 rotating components may be made for either design.

Depending on materials and components, **weight: 4 to 6 oz.**

MINIATURE (3 ELEMENT) SERVO GEAR TRAINS →

Two configurations are available to meet your mounting requirements (1.750" square or 1.188" wide by 2.500" long). In either design, gear ratios from motor to first rotating component of up to 1000:1 may be supplied, and up to 36:1 from the first rotating component to the second. Your choice of size 8 components for either design.

Depending on materials and components, **weight: 6 to 12 oz.**

Let CPPC Design Your Servo Package!

Perhaps the units shown are exactly what you have been looking for—or perhaps they are close to your needs. If not, the Systems Division of CPPC has the engineering knowledge and the production facilities to design and produce servo packages to your requirements—and all this supported by CPPC's precision rotating components of many varieties.

Why not give us the opportunity of reviewing your requirements for servo packages today.

For Further Information Telephone Or Write:

cppc SYSTEMS DIVISION

CLIFTON PRECISION PRODUCTS CO., INC.

Clifton Heights, Pennsylvania

Sales Department: 5050 State Rd., Drexel Hill, Pennsylvania
MAdison 2-1000, TWX LNSDWN, PA. 1122(U)—or our Representatives

CIRCLE NO. 75 ON INQUIRY CARD